

PB80-815855





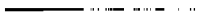

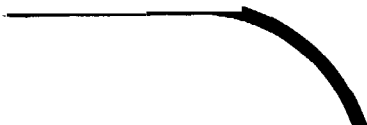
Ablation and Ablative Materials  
1974-July, 1980  
(Citations from the International  
Aerospace Abstracts Data Base)

New Mexico Univ.  
Albuquerque

Prepared for

National Technical Information Service  
Springfield, VA

Sep 80



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## BIBLIOGRAPHIC INFORMATION

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Samuel C. Mauk.

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These citations from the international literature concern various aspects of ablation and ablative materials. Included are articles covering aerodynamic heating, heat shielding, radiative heat transfer, atmospheric entry, re-entry effects, re-entry shielding and re-entry vehicles. Ablation of meteorites is also covered. Articles concerning various ablative materials are included. (This updated bibliography contains 290 citations, 90 of which are new additions to the previous edition.)

PRICE CODE: PC NO1/MF NO1

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#### ABSTRACT

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--78A23667--

Electrical Properties and Conduction Mechanisms of Ru-Based Thick-Film Cermet Resistors

A/Pike, G. E.; B/Seager, C. H.

Journal of Applied Physics, Vol. 48, Dec. 1977, p. 5152-5169. 18 pages.

ABS an investigation is made of the electrical conduction mechanisms in thick-film (cermet) resistors based on ruthenium. The temperature dependence of conductance, measured from 1.2-400 K, shows a significant decrease in conductance at low temperatures and a shallow maximum of several hundred kelvin. The reversible conductance as a function of electric field from 0-28 KV/CM is also considered. Electrical transport properties are evaluated for metal oxide particles extracted from fired resistors. Attention is given to various conduction mechanism models uniform, uniform channel, nontunneling barrier, and tunneling barrier model. Based on these results, a refined tunnel barrier model is developed and compared to experimental results.

/\*Cermets/\*Electrical Resistivity/\*Metal Oxides/\*Resistors/\*Ruthenium/\*Thick Films

#### SUBJECT TERMS

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80A37551

UTTL: Radiative heating of axisymmetric blunted bodies with a strongly ablating surface during reentry in the Jovian atmosphere

AUTH: A/CERASHOVA, E. A.; P/SUKHODOLSKAYA, E. IA.; C/SUKHODOLSKII, S. L.; D/TIRSKII, G. A.

In: Aerodynamics of hypersonic flows with fluid injection. (ABO-37551 15-02) Moscow, Izdatel'stvo Moskovskogo Universiteta, 1979, p. 121-138. In Russian.

ABS: In the present paper, the spectral heat fluxes to the surface of Jovian reentry vehicles are computed. The computations are carried out for spheres, paraboloids and hyperboloids of revolution, and truncated cones with spherical bluntness, both without injection and with injection of a C-O-H-H gas mixture. The rate of ablation of a textolite heat shield on a spherically blunted 60-degree cone is calculated

MAJS: /ABLATION/BLUNT BODIES/JUPITER ATMOSPHERE/RADIANT HEATING/REENTRY SHIELDING/SPACECRAFT REENTRY

80A37540

UTTL: Ablation of a body disintegrating under the action of intense radiation heating in its motion in a hydrogen-helium atmosphere

AUTH: A/NIKSKII, V. N.

In: High-speed aerodynamics. Number 5. (ABO-37524 15-02) Moscow, Izdatel'stvo Moskovskogo Universiteta, 1979, p. 100-104. In Russian.

ABS: The paper deals with the flow of a selectively radiating gas past the frontal surface of a spherical ablating reentry body provided with a phenol-impregnated carbon heat shield. The analysis is carried out for a model of the Jovian atmosphere (86% H<sub>2</sub>, 14% He).

MAJS: /ABLATION/GAS FLOW/HELIUM HYDROGEN ATMOSPHERES/JUPITER ATMOSPHERE/RADIANT HEATING/REENTRY VEHICLES

80A37553

UTTL: Intense destruction of bodies of laminar or granular structure in hypersonic flow

AUTH: A/APSHTEIN, E. Z.

In: Theoretical and experimental studies of hypersonic flows past bodies and in wakes. (ABO 37526 15-02) Moscow, Izdatel'stvo Moskovskogo Universiteta, 1979, p. 123-138. In Russian.

ABS: The paper deals with a material granular or laminar structure, composed of alternating radiation transmitting and nontransmitting zones. An expression for the heat exchange efficiency of the material is derived, and the nature of the destruction of the body

In a stagnation air flow is examined under the assumption of an optically thin boundary layer. The case of intense destruction, where the convective heat flux to the wall is zero and destruction occurs only under the action of radiant flux, is analyzed. An approximate analytical solution of the fluid film's equations of motion is obtained. The liquid and gas phase solutions lead to a system of transcendental equations for the destruction problem.

MAJS: /ABLATIVE MATERIALS/DESTRUCTIVE TESTS/GAS-SOLID INTERFACES/GRANULAR MATERIALS/HYPERSONIC FLOW/LAMINATES

80A31022

UTTL: Magnetic-field distortion near an ablating hydrogen pellet

AUTH: A/PARKS, P. B.

Nuclear Fusion, vol. 20, Mar. 1980, p. 311-320. Research supported by the Electric Power Research Institute.

ABS: A model is formulated to describe the distortion of the magnetic field near an ablating solid hydrogen pellet in a plasma. The resistive, collision-dominated ablation cloud expands across the magnetic field. The originally straight magnetic field lines threading the pellet and the ablating convect outward with the flow and at the same time diffuse inward, giving rise to a rarefaction of the field lines near the pellet. This effect reduces the incident electron energy flux to the ablating pellet. The resulting modest increase in pellet life-time implies a more favorable outlook for refueling tokamak reactors by pellet injection.

MAJS: /ABLATION/HIGH TEMPERATURE PLASMAS/HYDROGEN FUELS/MAGNETIC FIELD CONFIGURATIONS/PELLETS/TOYAMA DEVICES

80A31225

UTTL: The effect of chemical reactions of the injected gas on the aerodynamic heating of blunt bodies

AUTH: A/KARASHIMA, K.; B/NAKAMASHI, K.

(Tokyo, University, Institute of Space and Aeronautical Science, Bulletin, vol. 1978, p. 1111-1127.) Heat Transfer - Japanese Research, vol. 8, Jan.-Mar. 1979, p. 30-43. Translation.

ABS: The effects on aerodynamic heating of chemical reactions of gaseous materials injected into a shock layer flow due to ablation are examined. Assuming ablation of Teflon and equilibrium chemical reactions, a hypersonic flow past a blunt nosed axisymmetric body with surface injection of C<sub>2</sub>F<sub>4</sub> gas is solved numerically using the VSL equations, and a comparison is made with the results for an equivalent inert gas.

It is shown in the case of small coolant injection that a considerable increase in heating rate occurs in the stagnation region caused by the heating effect due to combustion of the coolant predominating over the effect of injecting cooling. Finally, it is stressed that the existing formula for estimating the heating rate with chemical reactions is invalid for predicting the real heating rate distribution over the surface with reactive coolant injection.

MAJS: /\*ABLATION/\*AERODYNAMIC HEATING/\*AEROTHERMOCHEMISTRY/\*BLUNT BODIES/\*CHEMICAL REACTIONS/\*GAS INJECTION/\*SHOCK LAYERS

UTTL: Comments on 'Effect of transonic flow in the ablation cloud on the lifetime of a solid hydrogen pellet in a plasma'

80A20562

UTTL: Comments on 'Effect of transonic flow in the ablation cloud on the lifetime of a solid hydrogen pellet in a plasma'

AUTH: A/LENGYEL, L. L.

Physics of Fluids, vol. 23, Mar. 1980, p. 656-658;

Author's Reply, p. 658.

MAJS: /\*ABLATION/\*HIGH TEMPERATURE PLASMAS/\*HYDROGEN/\*PLASMA-PARTICLE INTERACTIONS/\*SOLIDIFIED GASES/\*TRANSONIC FLOW

80A20054

UTTL: Lifetime measurements on atoms in compounds embedded in matrices using laser selective excitation and ablation dynamics

AUTH: A/KUONG, H. S.; B/MEASURES, R. M.

Applied Optics, vol. 19, Apr. 1, 1980, p. 1025-1027.

Research supported by the National Research Council of Canada;

MAJS: /\*ABLATION/\*ATOMIC EXCITATIONS/\*CHROMIUM COMPOUNDS/\*LASER APPLICATIONS/\*LASER TARGETS/\*RADIATIVE LIFETIME

80A25039

UTTL: Influence of fiber loading on the rain erosion behavior of polytetrafluoroethylene (PTFE)

AUTH: A/LEITSON, K. H.

In: International Conference on Erosion by Liquid and Solid Impact, 5th, Cambridge, England, September 3-6, 1979. Proceedings, (ABO-25030 05-23) Cambridge, Cambridge University, 1979, p. 16-1 to 16-10.

ABS: The effect of fiber loading on the rain erosion behavior of polytetrafluoroethylene (PTFE) has been investigated through use of Mach 5 sleds fired through an artificial rainfield. Molded PTFE specimens containing different loadings of aluminum silicate fibers, glass fibers, and mixtures of these two fibers. In addition to plain PTFE have been tested. Plain PTFE, tested previously at the same velocity.

provided performance data at zero percent fiber content and results for laminated compositions are included; supersonic single impact water jet experiments are also discussed.

MAJS: /\*ABLATION/\*FIBER COMPOSITES/\*LIQUID-SOLID INTERFACES/\*POLYTETRAFLUOROETHYLENE/\*RAIN EROSION/\*RAIN IMPACT DAMAGE

80A24326

UTTL: A computer program for transient and axisymmetric ablation, conduction and radiation

AUTH: A/FUSADE, L.; B/RIVAS, A.

In: Numerical methods in thermal problems: Proceedings of the First International Conference, Swansea, Wales, July 2-6, 1979. (ABO-24276 08-31) Swansea, Wales. Pineridge Press, Ltd., 1979, p. 1004-1013.

ABS: A transient ablation and heat transfer computer program which allows the analysis and design of systems of axisymmetric bodies subjected to high heat fluxes is described. The adaptive computation of the time step and the grid network and the availability of parameters for accuracy control allow a cheap and flexible use of the program.

MAJS: /\*ABLATION/\*ATMOSPHERIC ENTRY/\*COMPUTER PROGRAMS/\*REENTRY SHIELDING/\*THERMAL RADIATION/\*TRANSIENT HEATING

80A23848

UTTL: Influence of nonequilibrium radiation on heating of an ablating Jovian entry probe

AUTH: A/TIWARI, S. N.; B/SUBRAMANIAN, S. V. CORP: Old Dominion Univ., Norfolk, Va.

American Institute of Aeronautics and Astronautics. Aerospace Sciences Meeting, 18th, Pasadena, Calif., Jan. 14-16, 1980, 9 p.

ABS: The influence of non-local thermodynamic equilibrium (NLTE) radiative transfer on the entire shock-layer flow phenomena around a Jovian entry body is investigated. The flow in the shock layer is assumed to be viscous, axisymmetric, laminar, and in chemical equilibrium. The entry body considered is a 35-cm hyperboloid and the results have been obtained for the peak heating entry conditions. The results indicate that the radiative heating of the entry body is significantly higher under NLTE conditions.

MAJS: /\*ABLATIVE MATERIALS/\*JUNITER PROBES/\*RADIATIVE HEAT TRANSFER/\*REENTRY EFFECTS/\*SHOCK LAYERS/\*THERMODYNAMIC EQUILIBRIUM



80A22369

UTTL: A parameter characterizing the effect of thermooptical properties of a vitreous heat-shield material on its rate of melting due to radiative and convective heating

AUTH: A/SENCHENOV, A. S.  
(Inzhenerno-Fizicheskii Zhurnal, vol. 36, Apr. 1979, p. 508-590.) Journal of Engineering Physics, vol. 36, no. 4, Oct. 1979, p. 352-364. Translation.  
ABS: (Previously cited in Issue 13, p. 2349. Accession no. A79-32561)

MAJS: /-ABLATIVE MATERIALS/\*HEAT SHIELDING/\*OPTICAL PROPERTIES/\*QUARTZ/\*THERMOPHYSICAL PROPERTIES/\*VITREOUS MATERIALS

80A22276

UTTL: Spectral extinction coefficient of the vapors of a thermal protection material, ablated by a high-temperature air plasma flow

AUTH: A/GORIS, E. B.; B/IAKUSHIN, M. I.  
(Inzhenerno-Fizicheskii Zhurnal, vol. 38, Jan. 1980, p. 85-89. In Russian.)

ABS: Experimental results are presented on the optical properties of the boundary layer arising on an ablated model under conditions of convective and radiative heating. The laboratory simulation was carried out using an electrodeless plasmatron without impurities. The absolute radiation intensity of the ablation products was measured in the 0.3-0.9 micron wavelength range; the spectral extinction coefficient of the vapors was calculated from the transfer equations. The vapor extinction coefficient is found to be characterized by a high optical density.

MAJS: /-ABLATIVE MATERIALS/\*AERODYNAMIC HEATING/\*HIGH TEMPERATURE PLASMAS/\*OPTICAL PROPERTIES/\*REFRACTORY MATERIALS/\*THERMAL PROTECTION

80A21336

UTTL: Approximate method for determining mass transfer from the thermal-protection coating of a spacecraft during its ablation in the atmosphere

AUTH: A/KOZLAEV, V. G.  
Teori. Uchenye Zapiski, vol. 9, no. 5, 1978, p. 123-135. In Russian.

MAJS: /-ABLATION/\*ATMOSPHERIC ENTRY/\*MASS TRANSFER/\*PROTECTIVE COATINGS/\*SPACECRAFT SHIELDING/\*THERMAL CONTROL COATINGS

80A19255

UTTL: The theory of the fracture of heatproof ablating coatings

AUTH: A/PUZYREV, E. M.; B/TROITSKII, O. IU.  
(Fizika Goreniia i Vzryva, vol. 15, Mar.-Apr. 1979, p. 177-180.) Combustion, Explosion, and Shock Waves, vol. 15, no. 2, Sept. 1979, p. 271-274. Translation.  
ABS: (For abstract see Issue 18, p. 3423. Accession no. A79-42598)

MAJS: /-ABLATIVE MATERIALS/\*PYROLYSIS/\*THERMAL CONTROL COATINGS

80A1833C

UTTL: Thermal protection system for the Galileo mission atmospheric entry probe

AUTH: A/BREWER, R. A.; B/BRANT, D. N.  
American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 18th, Pasadena, Calif., Jan. 14-16, 1980, 13 p.

ABS: Carbon phenolic has been selected as the forebody heatshield material for the Galileo Probe Mission. The probe is currently designed to enter the Jupiter atmosphere at an entry velocity of 48.2 km/sec with an entry velocity of 7 to 10.2 deg, resulting in several centimeters of the carbonaceous heatshield being consumed by sublimation. The base thermal environment is also very severe, more than an order of magnitude greater than that of the Pioneer Venus probes, and phenolic nylon has been selected as the base thermal protection system. Unique design techniques have been developed to determine the probe's heat protection requirements. The predicted thermal environment, material response and safety margin philosophy are discussed in this paper.

MAJS: /-ABLATIVE MATERIALS/\*ATMOSPHERIC ENTRY/\*GALILEO PROBE /-HEAT SHIELDING/\*JUPITER ATMOSPHERE/\*THERMAL PROTECTION

80A16779

UTTL: Burn-through of thin aluminum foils by laser-driven ablation

AUTH: A/ARAD, B.; B/ELIEZER, S.; C/GAZIT, Y.; D/LOEENSTEIN, H. M.; E/ZIGLER, A.; F/ZMORA, H.; G/ZWEIGENBAUM, S.  
Journal of Applied Physics, vol. 50, Nov. 1979, pt. 1, p. 6817-6821.

ABS: The paper discusses irradiation of aluminum foils 1 to 75 microns thick by 500-psc Nd-glass laser pulses. The reflected and transmitted light and the produced X-rays were measured with PIN photodiodes and crystal spectrometers. Two torsion pendula measured the target and the plasma momenta with measurements consistent

with a simple hydrodynamic model. Plasma pressure in the 1.5 to 13 bar range, shock/wave velocities between 0.9 times 10 to the 6th and 2.6 times 10 to the 6th power cm/sec, and penetration depths of the ablation surface in the domain of 3 to 10 micron were obtained. The burn-through times for foils from 25 to 75 microns thick were measured.

MAJS: /ABLATION/ALUMINUM/BURNTHROUGH (FAILURE)/LASER PLASMAS/METAL FOILS/NEODYMIUM LASERS

80A16280

UTTL: Confinement of a plasma column by ablation fronts from cold gas plugs

AUTH: A/LIESE, W.; B/AHLBORN, B.; C/ARMSTRONG, B.  
Physics of Fluids, vol. 22, Dec. 1979, p. 2236-2299.  
Research supported by the National Research Council of Canada.

ABS: The paper describes an experimental test of the principle of gasdynamic end-plugging. In this experiment, a plasma column is produced and suddenly exposed to a cold gas at the same time producing a power flux to establish an ablation front. In this front the pressure is raised above that in the plasma column, so that particle confinement is achieved. The model of gasdynamic plugging of a linear plasma column is summarized. Pressure and particle velocity are measured as a function of the specific power and compared with model predictions. The experiments have shown that the ablation confinement of plasma columns by gas plugs operates as expected, that the particle velocity can be reversed, and that there is a maximum for the reversed flow which can be obtained by correct choice of the plug density.

MAJS: /ABLATIVE MATERIALS/COLD GAS/PLASMA CONTROL/PLASMA CYLINDERS

80A15228

UTTL: Influence of fiber loading on thermal ablation of PTFE

AUTH: A/LETSON, K. N.  
American Society of Mechanical Engineers, Intersociety Conference on Environmental Systems, 9th, San Francisco, Calif., July 16-19, 1979, 6 p.

ABS: The influence of fiber type and loading on the aerothermal ablation of polytetrafluoroethylene (PTFE) has been investigated through use of Mach-5 sled tests. PTFE specimens containing three different loadings of aluminum silicate ceramic fibers, two different loadings of equal parts of ceramic and glass fibers, and two loadings of glass fibers in addition to plain PTFE, have been tested. The PTFE specimen was tested to provide aerothermal ablation performance data for zero percent fiber content. Results indicate

that for minimizing aerothermal ablation, ceramic fiber is superior to glass, and the optimum ceramic fiber content is approximately 40 percent of the fiber loaded PTFE material.

MAJS: /ABLATIVE MATERIALS/AEROTHERMODYNAMICS/FIBER STRENGTH/GLASS FIBER REINFORCED PLASTICS/POLYTETRAFLUOROETHYLENE

80A13194

UTTL: Melting of solid bodies due to convective heating with the removal of melt

AUTH: A/PRASAD, A.  
Journal of Spacecraft and Rockets, vol. 16, Nov.-Dec. 1979, p. 445-448.

ABS: Heating and melting of ablating materials with the removal of melt due to convective or aerodynamic heating is of great significance in the design of protective layers of missiles and space vehicles. The paper analyzes the case where melting of the solid occurs due to convective heating and the melt is removed as soon as it is formed on the surface of the solid. The assumption that the solid is at its melting temperature is removed in order to account for the heating regime prior to melting. For both regimes, closed-form solutions are obtained. Numerical solutions are also provided.

MAJS: /ABLATION/CONVECTIVE HEAT TRANSFER/MELTING

80A12604

UTTL: Boron nitride ablation studies in arc jet facilities

AUTH: A/SHELDahl, R. E.; B/WRIGHT, G. F.; JR.; C/BEARD, S. G.; JR.  
In: International Instrumentation Symposium, 25th, Anaheim, Calif., May 7-10, 1979, Proceedings, Part 1, (ABO-12601 C2-35) Pittsburgh, Pa.: Instrument Society of America, 1979, p. 77-88. Research supported by the U.S. Department of Energy.

ABS: The use of boron nitride as an ablative material for antenna windows on high performance reentry vehicles necessitated an experimental study of its ablative behavior and thermal response in severe thermal environments. Boron nitride specimens were tested in three arc jet test facilities and the measured thermal response of the specimens shows good to excellent agreement with the results of computer analysis. Further studies are necessary to characterize the ablation mechanism of the molten material seen in motion pictures.

MAJS: /ABLATION/ABLATIVE MATERIALS/ARC JET ENGINE/BORON NITRIDES/REENTRY VEHICLES/SLOT ANTENNAS

80A12056

UTTL: Removal of mass from and change of shape of a three-dimensional body moving along a trajectory in the earth's atmosphere  
AUTH: A/APSHEIN, E. Z.; B/PILIUGIN, N. N.; C/FIRSKII, G. A.  
(Kosmicheskie Issledovaniia, vol. 17, Mar.-Apr. 1979, p. 246-255.) Cosmic Research, vol. 17, no. 2, Sept. 1979, p. 205-212. Translation.  
ABS: (For abstract see issue 14, p. 2540. Accession no. A79-34056)  
MAJS: /\*ABLATION/\*BODY KINEMATICS/\*EARTH ATMOSPHERE/\*MASS TRANSFER/\*REENTRY PHYSICS/\*REENTRY TRAJECTORIES/\*THREE DIMENSIONAL MOTION

79A54039

UTTL: Self-similar solutions in the destruction and melting problem with account for abrupt density change  
AUTH: A/DRUZHININ, G. V.; B/PAVLOV, V. G.  
(Aviatsionnaya Tekhnika, vol. 21, no. 4, 1978, p. 61-67.) Soviet Aeronautics, vol. 21, no. 4, 1978, p. 48-52. Translation.  
ABS: (For abstract see issue 12, p. 2196. Accession no. A79-32035)  
MAJS: /\*ABLATION/\*AERODYNAMIC HEAT TRANSFER/\*DESTRUCTIVE TESTS/\*HEAT SHIELDING/\*SIMILARITY THEOREM/\*THERMAL SIMULATION

79A53047

UTTL: Transport properties of monatomic carbon. II - Contributions from excited electronic states  
AUTH: A/BLOLSI, L.; B/BLOLSI, K. J. CORP: Missouri Univ. -Rolla.  
Journal of Geophysical Research, vol. 84, Sept. 1, 1979, p. 5311-5318.  
ABS: The aim of the present analysis is to verify the conventional assumption that the transport properties of atoms and molecules in excited electronic states are nearly the same as in the ground state. Reasonably exact calculations of the transport properties of excited-state carbon atoms are obtained on the basis of available experimental and theoretical data on the interactions between carbon atoms in excited electronic states. A comparison with results obtained with several models that have been used to estimate the transport properties of excited species indicates that the assumption under consideration is correct, but that the models do not predict very accurately the transport properties of excited species.  
MAJS: /\*ABLATIVE MATERIALS/\*ATOMIC EXCITATIONS/\*CARBON/\*HEAT SHIELDING/\*MONATOMIC MOLECULES/\*TRANSPORT PROPERTIES

79A50714

UTTL: Radiational properties of the decomposition products of a model around which flows a subsonic high-temperature plasma stream  
AUTH: A/GEORG, E. B.; B/IAKUSHIN, M. I.  
(Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza, Nov.-Dec. 1978, p. 76-80.) Fluid Dynamics, vol. 13, no. 6, May 1979, p. 854-857. Translation.  
ABS: (For abstract see issue 07, p. 1304. Accession no. A79-22435)  
MAJS: /\*ABLATIVE MATERIALS/\*CYLINDRICAL BODIES/\*HIGH TEMPERATURE PLASMAS/\*MAGNETOHYDRODYNAMIC FLOW/\*PLASMA RADIATION/\*SUBSONIC FLOW

79A50631

UTTL: Meteor flares - Particle separation processes  
AUTH: A/SIMCENKO, A. N.  
Meteoritika, no. 37, 1978, p. 69-73. In Russian.  
ABS: The times of brightness increase and decline of meteor flares is discussed. Specific causes of such flares are considered. It is suggested that a flare is caused by destruction of the heated surface of a meteoric body due to thermal stresses.  
MAJS: /\*ABLATIVE MATERIALS/\*AERODYNAMIC HEATING/\*ATMOSPHERIC ENTRY/\*METEORIDS

79A48504

UTTL: Statistical optimization of structural thermal protection material thickness  
AUTH: A/NIKIZAKOV, D. D.  
(Aviatsionnaya Tekhnika, vol. 21, no. 3, 1978, p. 81-84.) Soviet Aeronautics, vol. 21, no. 3, 1978, p. 57-60. Translation.  
ABS: (For abstract see issue 04, p. 593. Accession no. A79-16793)  
MAJS: /\*ABLATIVE MATERIALS/\*HEAT SHIELDING/\*THERMAL INSULATION/\*THICKNESS

79A42941

UTTL: Embeccing multidimensional ablation problems in inverse heat conduction problems using finite differences  
AUTH: A/RANCALL, J. D.  
In: International Heat Transfer Conference, 6th, Toronto, Canada, August 7-11, 1978, General Papers, Volume 3. (A79-42929 18-34) Washington, D.C., Hemisphere Publishing Corp., 1978, p. 129-134. ERDA-supported research.  
ABS: A unique numerical lumped parameter finite difference algorithm is presented for determining a material's thermal response to ablation. The unique feature of

the procedure is an embedding of the ablation problem in an inverse heat conduction problem which geometrically encloses it. The algorithm is applicable to multidimensional problems and permits the use of both implicit approximate factorization and explicit finite difference approximations. An application of the numerical method is demonstrated by applying it to the thermal analysis of a reentry body.

MAJS: /\*ABLATION/\*ALGORITHM/\*CONDUCTIVE HEAT TRANSFER/\*FINITE DIFFERENCE THEORY/\*NOSE CONES/\*REENTRY VEHICLES

79A42598

UTTL: Theory of the destruction of ablative thermal protection coatings

AUTH: A/PUZYREV, E. M.; B/TROITSKII, O. IU.

Fizika Goreniia i Vzryva, vol. 15, Mar.-Apr. 1979, p. 177-180. In Russian.

ABS: A mechanism for the destruction of ablative thermal protection coatings is proposed. In the model, high temperatures cause the pyrolysis of the thermal protection material, which is accompanied by the release of gaseous products and the formation of a porous coked layer. The thickness of the coked layer grows with time, leading to an increase in the pressure drop in the filtered gaseous products and the separation of the coked layer. The process is then repeated, with a frequency dependent on heating conditions and type of protective material. A simplified mathematical analysis of the process is presented in order to clarify various relationships in the problem.

MAJS: /\*ABLATIVE MATERIALS/\*PYROLYSIS/\*THERMAL CONTROL COATINGS

79A40476

UTTL: Analytical modeling of ramjet combustor heat transfer modes

AUTH: A/MELIA, P. F.

AIAA, SAE, and ASME, Joint Propulsion Conference, 15th, Las Vegas, Nev., June 18-20, 1979, AIAA 7 p.

ABS: An analytical model of charring heat transfer in an ablatively lined ramjet combustor correlated well with firings using either virgin linings or fully charred linings. Pyrolysis gas reactions were shown to be a significant heat transfer mechanism in certain regions. The model showed the existence of two qualitatively different heat transfer zones with similar total heat fluxes. An aft zone existed, characterized by a heat flux that was reactive and convective for actively charring linings. Linings in this zone, when fully charred, experienced only the

convective flux. A forward recirculation zone also existed, in which the heat transfer was convective and radiative in nature. In this zone, total flux was comparable to the total flux experienced in the aft zone for actively charring linings. However, this forward flux remained essentially the same for either charring of fully charred linings.

MAJS: /\*ABLATIVE MATERIALS/\*CHARRING/\*COMBUSTION CHAMBERS/\*HEAT TRANSFER/\*MATHEMATICAL MODELS/\*RAMJET ENGINES

79A38E03

UTTL: Ablative acceleration of laser-irradiated thin-film targets

AUTH: A/DECSTE, R.; B/BODNER, S. E.; C/RIPIN, B. H.; D/MCLEAN, E. A.; E/OBENSCHAIN, S. P.; F/ARMSTRONG, C. M.

Physical Review Letters, vol. 42, June 18, 1979, p. 1673-1677. Research sponsored by the U.S. Department of Energy.

ABS: Experimental and theoretical results are presented on ablative acceleration of thin-film targets at low laser irradiance (10 to the 12th-10 to the 13th W/sq cm). Ablative acceleration of foils up to about 10 to the 7th cm/sec, within a factor of 2 of what is required for pellet ignition, with a good hydrodynamic efficiency (about 20%) was obtained. These results are in reasonable agreement with the simple analogy to a rocket and are encouraging for laser fusion applications.

MAJS: /\*ABLATIVE MATERIALS/\*ACCELERATION/ FOILS (MATERIALS) /\*FUEL INJECTION/\*LASER FUSION

79A38567

UTTL: Numerical simulation of experiments in the Giant Planet Facility

AUTH: A/GREEN, M. J.; B/DAVY, W. C. CORP; National Aeronautics and Space Administration, Ames Research Center, Moffett Field, Calif.

American Institute of Aeronautics and Astronautics, Thermophysics Conference, 14th, Orlando, Fla., June 4-6, 1979, 13 p.

ABS: Utilizing a series of existing computer codes, ablation experiments in the Giant Planet Facility are numerically simulated. Of primary importance is the simulation of the low Mach number shock layer that envelops the test model. The RASLE shock-layer code, used in the Jupiter entry probe heat-shield design, is adapted to the experimental conditions. RASLE predictions for radiative and convective heat fluxes are in good agreement with calorimeter measurements. In simulating carbonaceous ablation experiments, the RASLE code is coupled directly with the CMA material

response code. For the graphite models, predicted and measured recessions agree very well. Predicted recession for the carbon phenolic models is 50% higher than that measured. This is the first time codes used for the Jupiter probe design have been compared with experiments.

MAJS: /\*ABLATIVE MATERIALS/\*ATMOSPHERIC ENTRY/\*COMPUTERIZED SIMULATION/\*HEAT SHIELDING/\*JUPITER PROBES/\*SHOCK LAYERS

79A38564

UTTL: Graphite materials ablation performance in high

thermal radiation environments

AUTH: A/BAKER, R. L.; B/CROWELL, P. G.

American Institute of Aeronautics and Astronautics, Thermophysics Conference, 14th, Orlando, Fla., June 4-6, 1979, 11 p.

ABS: The performance of graphite materials in advanced applications involving high radiation heat fluxes has been studied. Predicted results utilizing a recently developed nonequilibrium carbon ablation model have been compared with laser-heated ATU-S graphite ablation data. Possible explanation of the experimental results is obtained by using either: (1) modified JANNAF thermochemical data, assuming equilibrium gas-phase chemistry and that no melting occurred at measured temperatures up to 4484 K or (2) the Dolton- or Kratsch-recommended thermochemical data, assuming gas-phase frozen chemistry and a melt temperature of 4200 K. The implication of the latter interpretation is potentially severe degrading of graphite materials ablation performance due to decreased radiation absorption and melting.

MAJS: /\*ABLATIVE MATERIALS/\*CARBONACEOUS MATERIALS/\*GRAPHITE /\*HEAT FLUX/\*PERFORMANCE PREDICTION/\*THERMAL RADIATION

79A38154

UTTL: Limit mass loss by a body disintegrating under the action of intense radiative heating during its motion along a trajectory

AUTH: A/APSHEIN, E. Z.; B/EFIMOVA, L. G.; C/PILIUGIN, N. N.

In: Theoretical and experimental studies of hypersonic flows past bodies and hypersonic wakes. (A79-58152 16-02) Moscow, Izdatel'stvo Moskovskogo Universiteta, 1978, p. 22-29. In Russian.

ABS: The present paper deals with the problem of determining quantitatively the ablation of an entry probe. A numerical solution of the problem is obtained for the flow of an intensely emitting gas past a sphere. It is shown that the drag and heat-transfer

coefficient vary appreciably along the trajectory and that the body assumes a blunt configuration.

MAJS: /\*ABLATIVE MATERIALS/\*AERODYNAMIC HEATING/\*MASS TRANSFER/\*METEORITE COLLISIONS/\*RADIATIVE HEAT TRANSFER

79A38123

UTTL: Transient ablation of Teflon in intense radiative and convective environments

AUTH: A/ARAI, N. CORP: National Aeronautics and Space Administration, Ames Research Center, Moffett Field, Calif.

AIAA Journal, vol. 17, June 1979, p. 634-640.

ABS: On the basis of this investigation of the high-temperature behavior of polytetrafluoroethylene (PTFE), the transient one-dimensional ablation of PTFE has been developed by taking into account the optical transmittance of both the amorphous zone and the crystalline zone of PTFE layer. Results show that although the exposed surface receded at an apparently steady state, both the internal temperature and the thickness of the gel layer increase continuously due to the internal absorption of radiation.

MAJS: /\*ABLATION/\*AERODYNAMIC HEATING/\*CONVECTIVE HEAT TRANSFER/\*HEAT SHIELDING/\*HIGH TEMPERATURE TESTS/\*POLYTETRAFLUOROETHYLENE/\*RADIATIVE HEAT TRANSFER/\*TEFLON (TRADEMARK)

79A37122

UTTL: A quasi-simple ablation model for large meteorite entry - Theory vs observations

AUTH: A/REVELLE, C. O.

Journal of Atmospheric and Terrestrial Physics, vol. 41, May 1979, p. 451-473.

ABS: A single-body one-dimensional ablation model has been developed in order to predict the entry behavior of large meteorites during their hypersonic drag interaction with the earth's atmosphere. The entry predictions are compared with multistation photographic data. Typical results indicate that the ablation parameter, sigma, approximately equals 0.02-0.03 sq sec/sq km in the vicinity of the peak ablation altitude.

MAJS: /\*ABLATION/\*HYPERSONIC REENTRY/\*MATHEMATICAL MODELS/\*METEORITES/\*PERFORMANCE PREDICTION

79A36111  
 UTTL: Screening of selective radiation in a boundary layer  
 AUTH: A/KOHDRANIN, T. V.; B/KUZMINSKII, I. N.  
 (Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i  
 Gaza, Sept.-Oct. 1978, p. 71-77.) Fluid Dynamics, vol.  
 13, no. 5, Mar. 1979, p. 693-697. Translation.  
 ABS: (For abstract see Issue 03, p. 316, Accession no.  
 A79-14911)  
 MAJS: /\*ABLATIVE MATERIALS/\*BOUNDARY LAYERS/\*HEAT SHIELDING  
 /\*RADIATION SHIELDING/\*SHOCK LAYERS

79A34776  
 UTTL: An analytical investigation of the transient ablation  
 of teflon in convective and radiative environments  
 AUTH: A/ARAI, N.  
 Tokyo, University, Institute of Space and Aeronautical  
 Science, Report no. 570, vol. 44, Mar. 1979, p. 23-42.  
 On the basis of this investigation of the high  
 temperature behavior of polytetrafluoroethylene  
 (PTFE), the transient one-dimensional ablation of PTFE  
 has been developed by taking into account the optical  
 transmittance of both the amorphous zone and the  
 crystalline zone of PTFE-layer. Results show that  
 although the exposed surface receded at an apparently  
 steady state, both the internal temperature and the  
 thickness of the gel layer increase continuously due  
 to the internal absorption of radiation.  
 MAJS: /\*ABLATIVE MATERIALS/\*HEAT SHIELDING/  
 POLYTETRAFLUOROETHYLENE/\*TEFLON (TRADEMARK)

79A34656  
 UTTL: Mass ablation and angle in shape of a  
 three-dimensional body moving along a trajectory in  
 earth's atmosphere  
 AUTH: A/APSHTEIN, E. Z.; B/PILIUGIN, N. N.; C/TIRSKII, G.  
 A.  
 Kosmicheskie Issledovaniia, vol. 17, Mar.-Apr. 1979,  
 p. 246-255. In Russian.

ABS: The problem of determining mass ablation from a  
 three-dimensional body that changes its shape while  
 moving along a trajectory in earth's atmosphere is  
 examined. Heat fluxes that depend on the angle of  
 inclination of the surface with respect to the  
 velocity vector of the on-coming gas flow are  
 considered. Numerical results are presented for  
 several bodies of initially ellipsoidal shape with  
 different semiaxis ratios, which enter earth's  
 atmosphere with a velocity of 20 km/s and initial  
 entry angles of 9 to 90 deg. The radiative heat fluxes  
 incident on the body are computed by using approximate  
 formulas. It is shown that the change in mass, the  
 velocity, and the ballistic factor of the body are

functions of the various governing parameters.  
 MAJS: /\*ABLATION/\*BODY KINEMATICS/\*EARTH ATMOSPHERE/\*MASS  
 TRANSFER/\*REENTRY TRAJECTORIES/\*THREE DIMENSIONAL  
 MOTION

79A32661  
 UTTL: A parameter characterizing the influence of the  
 thermooptical properties of glassy heat shield  
 materials on their ablation rate under conditions of  
 heating by combined radiation and convection  
 AUTH: A/SENCHENKOV, A. S.  
 Inzhenerno-Fizicheskii Zhurnal, vol. 36, Apr. 1979, p.  
 588-590. In Russian.  
 MAJS: /\*ABLATIVE MATERIALS/\*GLASS/\*HEAT SHIELDING/\*OPTICAL  
 PROPERTIES/\*THERMOPHYSICAL PROPERTIES

79A32557  
 UTTL: Structure and observable characteristics of laser  
 driven ablation  
 AUTH: A/MATZEN, M. K.; B/MORSE, R. L.  
 Physics of Fluids, vol. 22, Apr. 1979, p. 654-658.  
 Research supported by the U.S. Department of Energy.  
 Numerical hydrodynamic-heat flow simulations of  
 spherical ablation have been done with sufficient  
 spatial resolution to show the details of the ablation  
 front structure. These simulations show a continuous  
 qualitative change in the velocity spectrum of  
 expanding ions with increasing laser pulse length,  
 ranging from approximately isothermal behavior from  
 short pulse to ablative behavior from longer pulses.  
 The ablative behavior is characterized by an energetic  
 peak in the ion spectrum, a characteristic of ablation  
 that is experimentally observable. The longer pulse  
 cases are found to be in good agreement with the  
 stationary flow model of ablation.  
 MAJS: /\*ABLATION/\*ION MOTION/\*LASER HEATING/\*PULSED LASERS/  
 THERMAL SIMULATION/\*VELOCITY DISTRIBUTION

79A32351  
 UTTL: Laser balancing demonstration on a high-speed flexible  
 rotor  
 AUTH: A/DEWATH, R. S.; B/RIO, R. A.; C/FLEMING, D. P.  
 CORP: Mechanical Technology, Inc., Latham, N. Y.;  
 National Aeronautics and Space Administration, Lewis  
 Research Center, Cleveland, Ohio.  
 American Society of Mechanical Engineers, Gas Turbine  
 Conference and Exhibit and Solar Energy Conference,  
 San Diego, Calif., Mar. 12-15, 1979, 6 p.  
 ABS: This paper describes a flexible rotor system used for  
 two-plane laser balancing and an experimental  
 demonstration of the laser material removal method for

balancing. A laboratory test rotor was modified to accept balancing corrections using a laser metal removal method while the rotor is at operating speed. The laser setup hardware required to balance the rotor using two correction planes is described. The test rig optical configuration and a neodymium glass laser were assembled and calibrated for material removal rates. Rotor amplitudes before and after balancing, trial and correction weights, rotor speed during operation of laser, and balancing time were documented. The rotor was balanced through the first bending critical speed using the laser material removal procedure to apply trial weights and correction weights without stopping the rotor.

MAJS: /\*ABLATION/\*BALANCING/\*FLEXIBLE BODIES/\*LASER DRILLING  
/\*MACHINING/\*NUMERICAL CONTROL/\*ROTORS

79A32035

UTTL: Similar solutions to the destruction and ablation problem with allowance for jumpwise density changes  
AUTH: A/DRUZHININ, G. V.; B/PAVLOV, V. G.  
Aviatsionnaya Tekhnika, vol. 21, no. 4, 1978, p. 61-67, in Russian.

ABS: The analysis deals with the solution of steady-state heat transfer problems for composite heat shields. The conditions under which the problem of destruction can be reduced to a self-simulating problem are identified from an analysis of the heat transfer equations within the framework of the theory of Lie groups.

MAJS: /\*ABLATION/\*AERODYNAMIC HEAT TRANSFER/\*DENSITY  
DISTRIBUTION/\*DESTRUCTIVE TESTS/\*HEAT SHIELDING/\*  
SIMILARITY THEOREM/\*THERMAL SIMULATION/\*UNSTEADY STATE

79A31335

UTTL: A meteor ablation-cluster ion atmospheric sodium theory  
AUTH: A/RICHTER, E. S.; B/SECHKIST, C. F., JR. CORP.  
Illinois Univ., Urbana.  
Geophysical Research Letters, vol. 6, Mar. 1979, p. 183-185.

ABS: Neutral and ionic forms of sodium form narrow, well-defined layers which peak in the 90-95 km altitude region at midlatitudes. A new theory for the sodium layer is presented, which is found to be in good agreement with existing atmospheric observations as well as available laboratory measurements of rate constants. The layer is believed to result naturally from a meteor ablation source over a chemical sink with vertical transport of Na(+) playing an important role in the layer shape and variation. While the neutral chemistry is believed to consist of chemical

equilibrium between Na and NaO, the ion chemistry departs from earlier studies and considers a cluster ion scheme. It is possible that higher-order cluster ions of sodium play a role in the formation of aerosols, through attachment or ion-induced nucleation processes.

MAJS: /\*ABLATIVE MATERIALS/\*ATMOSPHERIC CHEMISTRY/\*D REGION  
/\*METEOROLIDS/\*MIDLATITUDE ATMOSPHERE/\*SODIUM

79A28294

UTTL: An algorithm for automatically tracking ablating boundaries

AUTH: A/WEEKS, G. E.; B/COST, T. L.

International Journal for Numerical Methods in Engineering, vol. 14, no. 3, 1979, p. 441-449.

ABS: An algorithm for automatic computation of the position of the boundaries of structures with boundaries consisting of both ablating and nonablating parts is developed. The algorithm uses boundary nodal points on a planar region to define the structure boundary as the disjoint union of simple closed piecewise linear arcs. The algorithm calculates the position of the boundary nodal points at discrete times in an incremental fashion. When coupled with an automated mesh generation procedure, the ablation algorithm will automatically calculate the shape of an ablating structure at discrete times and generate a finite element mesh suitable for use in performing transient heat conduction or stress analyses.

MAJS: /\*ABLATION/\*ALGORITHMS/\*BOUNDARY VALUE PROBLEMS/\*  
CONTINUUM MECHANICS/\*FINITE ELEMENT METHOD/\*TRACKING  
(POSITION)

79A25583

UTTL: Hydrodynamic boundary conditions at the surface of an ablating material

AUTH: A/VASLOW, D. F.

Journal of Chemical Physics, vol. 69, Nov. 1, 1978, p. 4041-4045. Research supported by the Electric Power Research Institute.

ABS: The boundary conditions for a vapor at the surface of an ablating or vaporizing material are obtained. The vapor pressure, temperature, and mass flow rate are obtained when the initial state of the solid or liquid material and power absorbed at the phase transition layer are specified. These boundary conditions are derived from the hydrodynamic jump conditions and one equation from the thermodynamics of irreversible processes for a single component system. The results show that, for small mass flow rates, the vapor temperature rise is linearly proportional to the mass flow rate and the pressure drop varies as the square

of the mass flow rate. These dependencies are the reversal of Vulliet's results. Two application examples are considered: the ablation of iron, and the ablation of condensed hydrogen. It is shown that these boundary conditions for the ablation of condensed hydrogen are useful in studies of the refueling of present-day tokamak plasmas by injection of hydrogen pellets.

MAJS: /\*ABLATION/BOUNDARY LAYER FLOW/HYDRODYNAMICS/\*  
VAPORIZING

UTTL: 79A23885  
Slow deflagration - A mechanism for mass ablation from degenerate stars

AUTH: A/ERLUN, A.; B/RAKAVY, G.; C/YAHAL, R.  
Astrophysics and Space Science, vol. 60, no. 1, Jan. 1979, p. 77-98.

ABS: We investigate the structure of a slow reaction front on the surface of a dwarf, with a wake of escaping matter above it. We give simple expressions for all the important properties of such a front. It is found that a hydrogen or helium burning front is possible on a dwarf heavier than about one solar mass. For heavier fuels such a process seems impossible.

MAJS: /\*ABLATION/ASTROPHYSICS/DEFLAGRATION/DWARF STARS/\*  
STELLAR MASS EJECTION

79A23694

UTTL: Transient thermal response of ablating bodies

AUTH: A/ARAI, N.; B/KARASHIMA, K.-I. CORP: National Aeronautics and Space Administration, Ames Research Center, Moffett Field, Calif.; Tokyo Univ. (Japan).  
AIAA Journal, vol. 17, Feb. 1979, p. 191-195.

ABS: A numerical study of transient thermal response of a blunt-nosed axisymmetric body made of Teflon is presented using a two-layer thermal model. It is shown that phase change and transverse heat conduction have a considerable effect on the internal temperature field. Comparison of the numerical results with experimental data shows that the single-layer thermal model does not predict the real feature of the thermal field, whereas the results of the two-layer thermal model agree reasonably well with the experiment.

MAJS: /\*ABLATION/HEAT SHIELDING/NUMERICAL ANALYSIS/TEFLON/TRADEMARK/THERMAL SIMULATION/TRANSIENT RESPONSE

79A23546

UTTL: Effect of fiber fraction on ablation properties in short fiber graphite composites

AUTH: A/AUERBACH, I.  
American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 17th, New Orleans, La., Jan. 15-17, 1979, 12 p. Research supported by the U.S. Department of Energy.

ABS: The ablation performance of short-chopped fiber graphite composites, isostatically pressed, were studied in an arc-jet environment over the stagnation pressure and bulk gas enthalpy ranges of 12.7 to 20.7 MPa and 4648 to 6182 J/g, respectively. The fiber-volume fraction varied from 0.212 to 0.378. The time when proboscidean shape change was first observed and the time when conic shape change of the model face was complete were found to increase with the fiber fraction and inverse surface roughness. These parameters are also related to the ratios stagnation pressure/bulk enthalpy and the product of stagnation pressure and bulk enthalpy/(square root of model radius). Because proboscidean shape initiation time is delayed, the slower recession rates associated with laminar shape prevail and total recession is reduced. At stagnation pressures above 20 MPa, proboscidean shape initiation time becomes zero and thermal stress failure can occur. Surface roughness is inversely related to fiber content. A threshold value for surface roughness exists wherein the time required for proboscidean shape initiation increases over an order of magnitude.

MAJS: /\*ABLATION/CARBON FIBERS/FIBER COMPOSITES/PIROLYTIC GRAPHITE/REINFORCING FIBERS/THERMAL RESISTANCE

79A23530

UTTL: Shock tube spectroscopy of C3 + C2H mixture in the 140 to 700 nm range

AUTH: A/PRAKASH, S. G.; B/PARK, C. CORP: Stanford Univ., Calif.; National Aeronautics and Space Administration, Ames Research Center, Moffett Field, Calif.

American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 17th, New Orleans, La., Jan. 15-17, 1979, 8 p.

ABS: Absorption spectroscopy has been performed in the reflected-shock region of a shock tube. Acetylene was shock-heated to produce a mixture, at around 4000 K, rich in C3 and C2H to simulate the ablation layer over the Jovian entry probe, and the spectral range from 140 to 700 nm was surveyed with an evacuable spectrograph. The observed spectra were dominated by those of C2 and C3 and an unknown band at wavelengths below 300 nm. The cross sections of the C3 Swings band



In the 300 to 450 nm range agreed with previous measurements within a factor of 1.5. No absorption was observed in the wavelength range from 550 to 700 nm. The unknown broadband absorption with a peak cross section of 4 times 10 to the minus 17/sq cm at around 170 nm was attributed tentatively to the C2H radical. A preliminary calculation showed that the newly found absorption band would reduce the radiative heat flux to the stagnation point wall by about 12.5% in a typical flight condition.

MAJS: /-ABLATION/-ABSORPTION SPECTROSCOPY/-ATMOSPHERIC ENTRY /-GAS MIXTURES/-HEAT SHIELDING/-JUPITER ATMOSPHERE/-JUPITER PROBES/-SHOCK TUBES

79A22435

UTTL: Radiative properties of the decomposition products of a model in subsonic high-temperature plasma flow

AUTH: A/GEORG, E. B.: D/IAKUSHIN, N. I. Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhdkostei i Gaza, Nov.-Dec. 1978, p. 76-80. In Russian.

ABS: In the experiments described, asbestos-plastic models were tested, at atmospheric pressure, in a subsonic air stream heated to 8500 K. The complex structure of the multicomponent thermal boundary layer at the disintegrating surface of the model is examined, and the existence of a 1.5 to 2 mm long sublayer in the critical region of the boundary layer is pointed out. Both the temperature and the composition of the sublayer are fairly constant. The composition is defined essentially by the decomposition products of the model. The spectral distribution, in this region, of the radiation intensity of the asbestos-plastic vapors at 0.3 to 0.9 microns is determined and is used to calculate the spectral absorption coefficients for a temperature of 3300 K.

MAJS: /-ABLATIVE MATERIALS/-CYLINDRICAL BODIES/-HIGH TEMPERATURE PLASMA/-MACHETOHYDRODYNAMIC FLOW/-PLASMA RADIATION/-SUBSONIC FLOW

79A22279

UTTL: TABLASER - Trace /element/ analyzer based on laser ablation and selectively excited radiation

AUTH: A/MEASURE, R. M.: D/KOOP, H. S. Applied Optics, vol. 18, Feb. 1, 1979, p. 281-286. Research supported by the National Research Council of Canada and Environment Canada.

ABS: Trace element analysis based on laser ablation and selectively excited radiation (TABLASER) is proposed as a new and reliable multi-trace technique for quantitative in situ element analysis. Measurements of trace amounts of chromium in samples of NBS standard reference steel, doped skim milk powder, and doped

flour have been performed. Although the present sensitivity limit is in the ppm range, improved overlap between the probing dye laser beam and the wave of atomized material combined with a better design of the optical system could reduce the detection of the TABLASER to the ppb range. An important feature of this technique is its relative freedom from chemical matrix effects, which suggests the possibility of a universal calibration curve for all elements irrespective of the substrate matrix in which they are contained.

MAJS: /-ABLATION/-CHEMICAL ANALYSIS/-LASER MICROSCOPY/-LASER PLASMA INTERACTIONS/-RESONANCE FLUORESCENCE/-TRACE ELEMENTS

79A21639

UTTL: Influence of gaseous heat-shield destruction products on the heat transfer in the neighborhood of the stagnation point on a blunt body

AUTH: A/BIBERMAN, L. M.: B/BRONIN, S. IA.: C/BRYKIN, M. V. : D/VNATSAKIAN, A. KH. Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhdkostei i Gaza, May-June 1978, p. 129-136. Fluid Dynamics, vol. 13, no. 3, Dec. 1978, p. 440-447. Translation.

ABS: (For abstract see issue 18, p. 3264. Accession no. A78-43111)

MAJS: /-ABLATION/-AERODYNAMIC HEAT TRANSFER/-ATMOSPHERIC ENTRY/-BLUNT BODIES/-HEAT SHIELDING/-HYPERSONIC FLOW

79A21394

UTTL: Motion of bodies in the Jovian atmosphere, allowing for variation in their mass and shape due to aerodynamic heating

AUTH: A/GERSHBEIN, E. A.: B/SUKHODOLSKAIA, E. IA.: C/SUKHODOLSKII, S. L.: D/TIRSKII, G. A. (Kosmicheskie Issledovaniia, vol. 16, May-June 1978, p. 378-387.) Cosmic Research, vol. 16, no. 3, Nov. 1978, p. 303-311. Translation.

ABS: (For abstract see issue 17, p. 3034. Accession no. A78-41350)

MAJS: /-ABLATION/-AERODYNAMIC HEATING/-ATMOSPHERIC ENTRY/-DESCENT TRAJECTORIES/-JUPITER ATMOSPHERE/-JUPITER PROBES

79A19492

UTTL: Heat shield material tests in a simulated Jovian entry heating environment

AUTH: A/MEZINES, S. A.: B/MASEK, R. V. American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 17th, New Orleans, La., Jan. 15-17, 1979, 10 p.

**ABS:** Performance test data of candidate materials proposed for the Galileo probe heat shield are presented and compared with ablation theory. The tests were conducted in a high-energy centrifuge facility recently developed to simulate the Jovian entry heating environment. The test condition is characterized by a heating rate of 17.3 kW/sq cm, a stagnation pressure of 1.1 atmospheres, a centerline enthalpy of 407 MJ/kg and a gas stream composition of 50% hydrogen-50% helium by volume. The measured carbon phenolic and Al<sub>2</sub>O<sub>3</sub>-5 graphite recession data are used to calibrate the mass-transfer cooling relationships for application to Jovian atmospheric conditions. Movies taken during the tests and examination of the specimens after testing indicate relatively smooth recession characteristics without evidence of any spallation or particulate mass-loss problems.

**MAJS:** /•ABLATIVE MATERIALS/•ATMOSPHERIC ENTRY SIMULATION/• GALILEO PROJECT/•HEAT SHIELDING/•JUPITER PROSES/• THERMAL CONTROL COATINGS

**79A18392**  
**UTTL:** Numerical solution of the entrainment equation  
**AUTH:** A/ZHAR'ENSKII, V. V.  
 (Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza, Mar.-Apr. 1978, p. 147-154.) Fluid Dynamics, vol. 13, no. 2, Nov. 1978, p. 282-288. Translation. (For abstract see issue 14, p. 2526, Accession No. A78-35912)  
**MAJS:** /•ABLATION/•AERODYNAMIC HEATING/•CONVECTIVE HEAT TRANSFER/•MASS TRANSFER/•NUMERICAL ANALYSIS/•PANT PROGRAM

**79A18391**  
**UTTL:** Stationary shape of bodies during their rupture because of aerodynamic heating  
**AUTH:** A/•ORONKIN, V. G.; B/LUNEV, V. V.; C/NIKULIN, A. N.  
 (Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza, Mar.-Apr. 1978, p. 138-146.) Fluid Dynamics, vol. 13, no. 2, Nov. 1978, p. 274-281. Translation. (For abstract see issue 14, p. 2526, Accession No. A78-35911)  
**MAJS:** /•ABLATION/•ABLATIVE NOSE CONES/•AERODYNAMIC HEATING

**79A18264**  
**UTTL:** Supersonic rain erosion behavior of ablative fluorocarbon plastic radome materials  
**AUTH:** A/SCHWITT, G. F., JR.  
 In: Symposium on Electromagnetic Windows, 14th, Atlanta, Ga., June 21-23, 1978, Proceedings. (A79-18251 CS-27) Atlanta, Ga., Georgia Institute of

Technology, 1978, p. 87-96.  
**ABS:** A study was performed to characterize the erosion behavior of several ablative plastics (including Duroid and Avcoat materials) in a supersonic (Mach 4) rain encounter and, more particularly, to determine the influence of reinforcement types (fibers vs. particulate) and processing (laminated vs. molded) on their rain erosion resistance. The excellent erosion performance of the fiber reinforced Ieflon Duroid materials and the new elastomeric fluorocarbon Avcoat 8028 was demonstrated a new class of materials for primary thermal protection of tactical missile radomes.

**MAJS:** /•ABLATIVE MATERIALS/•FLUOROCARBONS/•RADOME MATERIALS /•RAIN EROSION/•SUPERSONIC FLIGHT

**79A18256**  
**UTTL:** Design of an ablative missile radome for use with a shape beam antenna  
**AUTH:** A/KOZAKOFF, D. J.; B/OSSIN, A.  
 In: Symposium on Electromagnetic Windows, 14th, Atlanta, Ga., June 21-23, 1978, Proceedings. (A79-18251 CS-27) Atlanta, Ga., Georgia Institute of Technology, 1978, p. 29-34.

**ABS:** A simple two-dimensional worst case analysis was used to evaluate the feasibility of an ablative radome concept for use with a Ku-band circularly polarized shape beam ground mapping radar antenna. The criterion for acceptance was a maximum plus or minus 1 dB departure of the antenna pattern from the ideal pattern in the mapping region. Antenna patterns for various fiberglass core materials and ablator material and thickness combinations were computed. Fabrication and testing of a selected fiberglass Duroid concept demonstrated acceptable pattern distortions as predicted by the theory.

**MAJS:** /•ABLATIVE MATERIALS/•BEAMS (RADIATION)/•DESIGN ANALYSIS/•MISSILE ANTENNAS/•RADAR ANTENNAS/•RADOME MATERIALS

**79A17628**  
**UTTL:** A novel technique for determining the enthalpy profile of flow from an arc heated wind tunnel  
**AUTH:** A/METZGER, J. W.  
 In: International Instrumentation Symposium, 24th, Albuquerque, N. Mex., May 1-5, 1978, Proceedings, Part 2. (A79-17576 OS-35) Pittsburgh, Pa., Instrument Society of America, 1978, p. 655-662.  
**ABS:** To implement a program for the study of the oxidative ablation of selected metals, detailed calibrative measurements of the flow from an arc heated wind tunnel were obtained. The calibrations, which profiled

the entire exit plane of the nozzle, included a determination of the enthalpy of the flow based on the ablation of Teflon. After evaluation to determine the validity of their responses, cylindrical rod calorimeters measured directly the heat transfer to a cylindrical shape placed normal to the flow. Corresponding cylindrical rods of Teflon were ablated and the results were combined with the heat transfer measurements to generate an enthalpy profile based on the theoretical heat of ablation of Teflon. The experimental procedures are discussed and the results presented along with an evaluation of the results in comparison to bulk enthalpy measurements. The results indicate that the method provides a valid technique for obtaining a profile of enthalpy in a hypothermal flow.

MAJS: /•ABLATIVE MATERIALS/•ARC HEATING/•ENTHALPY/•WIND TUNNEL CALIBRATION

79A17622

UTTL: Flow field calibration results for the AEDC High Enthalpy Ablation Test Facility /HEAT/

AUTH: A/HOFKY, D. C.

In: International Instrumentation Symposium, 24th, Albuquerque, N. Mex., May 1-5, 1978, Proceedings, Part 2. (A79-17576 05-35) Pittsburgh, Pa.: Instrument Society of America, 1978, p. 503-514.

ABS: Radial and axial pressure, heating and enthalpy surveys were made in parallel nozzle flow fields exiting from a new segmented arc heater called the Arnold Engineering Development Center (AEDC) High Enthalpy Ablation Test Facility (HEAT). Test instrumentation included null point calorimeters, transient pressure probes and a transient enthalpy probe. Probe diameters ranged from 0.08 inch to 1.00 inch while run conditions included maximum chamber pressures, heat transfer rates and bulk enthalpies of 125 atm, 2800 BTU/sq ft-sec, and 4000 BTU/lb, respectively. Test results are presented including comparisons with ideal flow predictions for heating, effective nose radii, pressure gradients and derived enthalpy. The limitations of finite body-flow field interaction with regard to flight simulation are discussed and compared with data from other arc heaters.

MAJS: /•ABLATION/•AERODYNAMIC HEATING/•CALIBRATING/•FLIGHT SIMULATION/•FLOW DISTRIBUTION/•TEST FACILITIES

79A16793

UTTL: Statistical optimization of heat shield thickness AUTH: A/NIKIZAKOV, D. D.

Aviatsionnaya Tekhnika, vol. 21, no. 3, 1978, p. 81-84. In Russian.

ABS: Some aspects are examined of the problem of determining the optimal thicknesses of heat shields on the basis of selected statistical data on the erosion and ablation of the material. Statistical heat-shield optimization problems are formulated, and relations for calculating optimal thicknesses for a normal erosion distribution law are derived. The effectiveness and reliability of the relations is demonstrated by examples.

MAJS: /•ABLATIVE MATERIALS/•HEAT SHIELDING/•THERMAL INSULATION/•THICKNESS

79A14911

UTTL: Study of selective-radiation shields in boundary layers

AUTH: A/KONCRANIN, T. V.; B/KUZMINSKII, I. N.

Akademika Nauk SSSR, Izvestiya, Mekhanika Zhidkosti i Gaza, Sept.-Oct. 1978, p. 71-77. In Russian.

ABS: Analysis of the spectral characteristics of heat shields has shown that radiation at wavelengths greater than 0.5 micron plays an important part in radiation heating and disintegration of surface materials. In the present paper, an attempt is made to identify the spectroscopic properties of diatomic and triatomic molecules which could provide effective shielding from radiation in this spectral range.

MAJS: /•ABLATIVE MATERIALS/•BOUNDARY LAYERS/•HEAT SHIELDING/•RADIATION SHIELDING

79A13907

UTTL: Use of generalized diffusion coefficients in solving conjugate problems

AUTH: A/GLEBOV, G. A.

(Inzhenerno-Fizicheskii Zhurnal, vol. 33, Dec. 1977, p. 1001-1006.) Journal of Engineering Physics, vol. 33, no. 6, June 1978, p. 1422-1426. Translation.

ABS: (For abstract see issue 10, p. 1703, Accession no. A78-27457)

MAJS: /•ABLATIVE MATERIALS/•AERODYNAMIC HEATING/•DIFFUSION COEFFICIENT/•GRAPHITE/•HEAT SHIELDING/•MATHEMATICAL MODELS

79A13618

**UTTL:** Thermal property evaluation for ablative materials in plasma arc jet facility

**AUTH:** A/NARAYANAN, K. N.  
In: National Heat and Mass Transfer Conference, 4th, Roorkee, India, November 21-23, 1977, proceedings, (A79-13576 C3-34) Meerut, India, Sarita Prakashan, 1978, p. 993-1008.

**ABS:** Thermal properties of ablative materials used in rocket nozzles are required accurately for reliable and optimum design of nozzles. Present paper outlines the evaluation work carried out for properties like heat of ablation, heat of pyrolysis, virgin and char densities and mass ablation rates for carbon and silica phenolic materials using the 100 kw plasma arc jet facility at the heat transfer laboratory in this section. Solid cylindrical specimens of the test materials were exposed for specific times in the calibrated jet. The cold wall heat flux was estimated by calorimetry. From the corrected heat flux, mass loss, ablation rate, stream parameters and temperature records at various depths, the properties were estimated. It is found that the data obtained were in considerable agreement with the data from already published literature.

**MAJS:** /\*ABLATIVE MATERIALS/\*PLASMA JETS/\*ROCKET NOZZLES/\* THERMAL RESISTANCE/\*THERMODYNAMIC PROPERTIES

79A13616

**UTTL:** Experimental determination of temperature distributions and char depth histories in ablative nozzles of solid propellant rocket motors

**AUTH:** A/RAO, S. V. S.  
In: National Heat and Mass Transfer Conference, 4th, Roorkee, India, November 21-23, 1977, proceedings, (A79-13576 C3-34) Meerut, India, Sarita Prakashan, 1978, p. 893-892.

**ABS:** Transient temperature distributions and char depth histories have been determined in the asbestos phenolic and silica phenolic ablative liners of the nozzle divergent in a solid-propellant rocket motor developing a thrust of about 2000 kg. The measurements were made using 0.25-mm-diam chromel-alumel thermocouples. An existing-type thermocouple was used to determine exposed surface temperature. For asbestos phenolic ablative material, an ablation temperature of about 1710 C was found. Char depth histories were determined using a char interface recession rate sensor.

**MAJS:** /\*ABLATIVE MATERIALS/\*NOZZLE INSERTS/\*SOLID PROPELLANT ROCKET ENGINES/\*TEMPERATURE DISTRIBUTION/\*TEMPERATURE MEASUREMENT

79A11284

**UTTL:** Propagation of a blunt body through the dense atmosphere under conditions of severe aerodynamic heating and ablation

**AUTH:** A/BIBERMAN, L. M.; B/BRONIN, S. I.A.; C/BRYKIN, M. V.  
International Astronautical Federation, International Astronautical Congress, 29th, Dubrovnik, Yugoslavia, Oct. 1-8, 1978, 22 p.

**ABS:** Propagation of a body through the earth's atmosphere at velocities up to tens of km/sec and the ablation of the body due to aerodynamic heating are investigated. Major results concerning the flow field and heat transfer in the bow shock layer are presented. These results are then used to interpret available data on trajectories and light curves of bright fireballs.

**MAJS:** /\*ABLATION/\*AERODYNAMIC HEATING/\*ATMOSPHERIC ENTRY/\* BLUNT BODIES/\*HYPERSONIC FLIGHT

78A53590

**UTTL:** Laser acceleration of reactor-fuel pellets

**AUTH:** A/FELEER, F. S.  
Nuclear Fusion, vol. 18, Oct. 1978, p. 1469-1471.  
Research supported by the Electric Power Research Institute.

**ABS:** A method for fuelling a fusion power reactor by the injection of pellets accelerated by laser-produced ablation is reported. Estimates suggest that present laser technology is adequate for accelerating fuel pellets to a velocity required for the fuelling of a demonstration thermonuclear reactor. The laser requirements are energies of tens of kJ, pulse widths of tens of microsec, intensities of about  $1 \text{ GJ/sq cm}$  focused over a 10-cm pellet trajectory, and a repetition rate of tens of Hz.

**MAJS:** /\*ABLATION/\*FUSION REACTORS/\*HIGH ACCELERATION/\*LASER FUSION/\*LASER PLASMA INTERACTIONS/\*PELLETS

78A53508

**UTTL:** Mutual effect of thermochemical destruction of the surface and viscous interaction for hypersonic flow past a sharp cone

**AUTH:** A/LIANSKII, A. V.; B/IMOSHENKO, V. I.  
Kosmicheskii Issledovanie na Ukraine, no. 11, 1977, p. 23-26. In Russian.

**ABS:** Numerical results on the hypersonic gas flow in viscous interaction regime past sharp circular cones with thermally destructible surface are presented. Characteristics of the mutual influence between the thermochemical destruction of the surface and the viscous interaction are revealed.

**MAJS:** /\*ABLATIVE MATERIALS/\*AERODYNAMIC HEATING/\* AEROTHERMOCHEMISTRY/\*CONICAL FLOW/\*HYPERSONIC FLOW/\*

## SURFACE PROPERTIES

78A50457

**UTTL:** Investigation of a side force due to ablation  
**AUTH:** A/RAGSDALE, W. C.; B/HORANOFF, E. Y.  
**ABSTRACT:** A study has been made of the effects of ablation-induced side forces in reentry vehicle stability. Ablating and nonablating spherically blunted cone models were examined at Mach 18 in hypervelocity wind tunnels. The model was spun to the desired rate while the wind-tunnel supply pressure and temperature were brought to the run condition. When the conditions were achieved, the model was injected into the tunnel flow and force data were recorded. Side force data were plotted with and without ablation, with ablation at different spin rates, and with ablation at different Reynolds numbers.  
**MAJIS:** ABLATION/AERODYNAMIC HEATING/•FORCE DISTRIBUTION/•HYPERSONIC REENTRY/•SPIN DYNAMICS/•WIND TUNNEL STABILITY TESTS

78A50455

**UTTL:** Effect of temperature-dependent heat capacity on aerodynamic ablation of melting bodies  
**AUTH:** A/PRASAD, A.  
**ABSTRACT:** The influence of temperature-dependent heat capacity on the ablation and temperature buildup at the surface of melting bodies is considered for the case where melting occurs due to aerodynamic heating. The melting body is assumed to be a semiinfinite solid having a constant cross-sectional area. Solutions are found by a variational method which predicts the surface-temperature time history and the melting-distance time history. Results in closed form are presented along with numerical solutions.  
**MAJIS:** ABLATION/AERODYNAMIC HEATING/•MELTING/•SPECIFIC HEAT/•SURFACE TEMPERATURE

78A47055

**UTTL:** Infrared laser ablation of polymers  
**AUTH:** A/COZZENS, R. F.; B/FOX, R. B.  
**ABSTRACT:** Ablation produced by 10.6-micron laser irradiation of eleven polymers is reported. Polymers which formed a carbonaceous residue were found to have much higher ablation energies than cleanly ablating polymers. All non-char-forming polymers studied had observed laser ablation energies in the range 3.4-3.9 kJ/g except for

poly(alpha-methylstyrene) which had a value of 2.4 kJ/g. The low value for poly(alpha-methylstyrene) is attributed to an exceptionally efficient depolymerization. The observed ablation energy of poly(methyl methacrylate) was found to decrease with increasing irradiance up to about 15 W/sq cm, reaching a constant value of 3.5 kJ/g at irradiances between 20 and 2000 W/sq cm. The proposed process of laser ablation is one that involves random fragmentation resulting from the accumulation of vibronic energy.  
**MAJIS:** ABLATION/•INFRARED LASERS/•LASER HEATING/•POLYMER CHEMISTRY/•PYROLYSIS

78A49547

**UTTL:** Supersonic rain erosion behavior of ablative fluorocarbon plastic ramjet materials  
**AUTH:** A/SCHULTZ, G. F.; JR.  
**ABSTRACT:** SAE Journal, vol. 14, Sept.-Oct. 1978, p. 13-17. The erosion behavior of fiber-reinforced and particulate-loaded fluorocarbon plastics was tested at Mach 4.0 in a simulated rain environment on a supersonic rain erosion wedge. Both molded and laminated materials demonstrated excellent erosion performance, although fiber-reinforced material showed itself to be superior to particulate-loaded material in this respect. Glass-reinforced material was superior to aluminum silicate-reinforced material. Thick sections of elastomeric fluorocarbons compounded with fillers exhibit excellent erosion resistance even at 1300 m/sec if used in thicknesses of 0.5 inch. Erosion rate with the materials tested was found to vary with the 1.5-2.0 power of the sine of the impact angle and the 2.7-3.5 power of the normal velocity component.  
**MAJIS:** ABLATIVE MATERIALS/•FLUOROCARBONS/•RADOME MATERIALS/•RAIN EROSION/•REINFORCED PLASTICS/•SUPERSONIC SPEEDS

78A47017

**UTTL:** Thermal response of an ablation-transpiration-cooled system in a radiative and convective environment  
**AUTH:** A/KUBOTA, M.  
**ABSTRACT:** In: International Symposium on Space Technology and Science, 12th, Tokyo, Japan, May 16-20, 1977. Proceedings. (A78-47001 21-12) Chofu, Tokyo, National Aerospace Laboratory, 1977, p. 127-132. Research supported by the National Research Council. The unsteady thermal response of a one-dimensional ablation-transpiration-coupled cooling system consisting of a reflecting porous matrix and an injected absorbing gas in a radiative and convective environment is presented. The solid and gas

temperatures and the gas pressure distributions within the porous matrix, the surface ablation rate, and the back-face heat transfer rate are obtained for a sample case of a 15 deg entry into a Saturn nominal atmosphere with the use of silica for the porous matrix and carbon dioxide for the transparent gas, for typical parameters of mass injection rate, porosity of the matrix, and matrix thickness. It is found that the surface temperatures, the surface ablation rate, and the back-face heat transfer rate quickly respond to the incident radiative pulse, and the surface temperatures are kept lower than those of transpiration-cooled system, showing the usefulness of this cooling system for the thermal protection.

MAJS: /•ABLATIVE MATERIALS/•ATMOSPHERIC ENTRY/•COOLING SYSTEMS/•SPACE PROBES/•SWEAT COOLING/•THERMAL PROTECTION/•TRANSPIRATION

78A44640

UTTL: Method for reducing ablation in a supersonic plasma flow

AUTH: A/SULTANOV, M. A.  
(Zhurnal Tekhnicheskoi Fiziki, vol. 47, Oct. 1977, p. 2213-2216.) Soviet Physics - Technical Physics, vol. 22, Oct. 1977, p. 1297-1209. Translation.

ABS: (For abstract see issue 07, p. 1263. Accession no. A78-21267)

MAJS: /•ABLATION/•ATMOSPHERIC ENTRY SIMULATION/•CONDUCTIVE HEAT TRANSFER/•MAGNETOHYDRODYNAMIC FLOW/•PLASMA SPRAYING/•SUPERSONIC FLOW

78A43586

UTTL: Finite element analysis of structures with ablating boundaries

AUTH: A/COST, T. L.; B/WEEKS, G. E.  
American Institute of Aeronautics and Astronautics and Society of Automotive Engineers, Joint Propulsion Conference, 14th, Las Vegas, Nev., July 25-27, 1978. AIAA 5 p.

ABS: An algorithm has been developed which automatically calculates the time-dependent positions of points on the ablating boundaries of two-dimensional continuum structures with geometrically complex shapes. The boundary may consist of ablating and nonablating parts. The initial ablating and nonablating boundaries are defined by the disjoint union of piecewise linear arcs passing through a finite set of nodal points on the boundary, each defined by a pair of rectangular cartesian coordinates. For a specified ablation rate, the algorithm calculates successive positions of the boundary points at times specified by the user. The algorithm is designed such that it may be easily

incorporated, along with an automated mesh generation procedure, into existing finite element codes for transient thermal or stress analysis of structures with ablating boundaries. Two examples are presented from the field of solid rocket analysis.

MAJS: /•ABLATIVE MATERIALS/•FINITE ELEMENT METHOD/•SOLID PROPELLANT ROCKET ENGINES/•STRUCTURAL ANALYSIS/•TWO-DIMENSIONAL BODIES

78A43111

UTTL: The effect of gaseous ablation-products of a thermal-protection coating on heat transfer near the critical point of a blunt body

AUTH: A/BIBERNAN, L. M.; B/BRONIN, S. I.A.; C/ERYKIN, M. V.  
; D/ANATSAKIAN, A. KH.

ABS: Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhukovskii Gaza, May-June 1978, p. 129-136. In Russian.

ABS: The paper considers the heat transfer characteristics at critical point of a blunt body undergoing ablation at hypersonic speed in the earth atmosphere under conditions of intense blowing. The protective coating vaporizes and the vapor pressure causes the boundary layer to separate from the surface of the body. As a result, an inviscid vapor layer is formed at the surface, underlying a thinner layer where vapor and gas are mixed. Under intense-blowing conditions, the surface of the body undergoes only radiative heating, with convective heat fluxes absent.

MAJS: /•ABLATION/•AERODYNAMIC HEAT TRANSFER/•ATMOSPHERIC ENTRY/•BLUNT BODIES/•HYPERSONIC FLOW/•PROTECTIVE COATINGS

78A42646

UTTL: An analytical model of the transient ablation of polytetrafluoroethylene layers

AUTH: A/HOLZKNECHT, B.  
International Journal of Heat and Mass Transfer, vol. 20, June 1977, p. 661-668.

ABS: Pyrolysis experiments with polytetrafluoroethylene (PTFE) in a closed volume, which investigate the mechanism of depolymerization, the influences of sample size and of different gas atmospheres as well as the composition of the reaction products, are analyzed with respect to unilaterally heated PTFE-layers. On the basis of this investigation of the high-temperature behaviour of PTFE an analytical model for the transient one-dimensional ablation of PTFE-layers has been developed. The crystalline-amorphous phase transition, the thermal expansion and the formation of higher-molecular products at the surface are taken into account. Comparisons of computed temperature profiles with

measured values in plasma-arc jet facilities confirm the model for transient ablation and the limiting case of quasi-steady ablation.  
MAJS: /•ABLATIVE MATERIALS/•HIGH TEMPERATURE TESTS/•POLYTETRAFLUOROETHYLENE/•PYROLYSIS

78A41879  
UTTL: The impact of turbulence on a radiating shock layer with coupled ablation injection  
AUTH: A/MOSS, J. N.; B/SIMMONDS, A. L.; C/ANDERSON, E. C. CORP. National Aeronautics and Space Administration. Langley Research Center, Langley Station, Va. American Institute of Aeronautics and Astronautics, Fluid and Plasma Dynamics Conference, 11th, Seattle, Wash., July 10-12, 1973, 17 p.

ABS: This paper provides a description of the potential impact of turbulence on a radiating flow field with large surface blowing. This is accomplished by calculating the forebody flow field with coupled carbon-phenolic mass injection for a probe entering the Jupiter atmosphere. Both laminar and turbulent flow conditions are assumed, for the no blowing solutions. Turbulence is shown to have no impact on the surface radiative heating. However, with ablation injection, turbulence significantly increases the surface radiative heating rate. This occurs because the turbulence brings the high temperature gases closer to the surface, thus thinning the cool molecular gases at the wall which are responsible for blocking much of the radiation.

MAJS: /•ABLATIVE MATERIALS/•FLOW DISTRIBUTION/•JUPITER PROBE/•RADIATIVE HEAT TRANSFER/•SHOCK LAYERS/•TURBULENT FLOW

78A41358  
UTTL: Motion of objects in the Jovian atmosphere with allowance for changes in their mass and configuration under the action of aerodynamic heating  
AUTH: A/GERSHBEIN, E. A.; B/SUKHODOLSKAIA, E. IA.; C/SUKHODOLSKII, S. L.; D/TIRSKII, G. A. Kosmicheskie Issledovaniia, vol. 16, May-June 1978, p. 378-387. In Russian.

ABS: The entry of probes into the Jovian atmosphere at speeds of 40 to 60 km/sec is analyzed with allowance for ablation. The equations of radiation gasdynamics are solved simultaneously with the equations of motion of the probe. Changes in the ballistic factor, due to ablation are taken into consideration. The thermal radiation fluxes are calculated with allowance for continuum and line radiative transfer. The influence of ablation on the descent path of a graphite-coated probe is determined.

MAJS: /•ABLATION/•AERODYNAMIC HEATING/•ATMOSPHERIC ENTRY/•DESCENT TRAJECTORIES/•JUPITER ATMOSPHERE/•JUPITER PROBES

78A41C56  
UTTL: Transport properties of monatomic carbon  
AUTH: A/BLOSI, L. CORP. Missouri Univ., Rolla, Journal of Geophysical Research, vol. 83, June 1, 1978, p. 2476-2480.

ABS: Transport collision integrals for each of the 18 molecular C2 states that dissociate into ground state carbon atoms are presented. The integrals are obtained by fitting two-body semiempirical interaction potentials, for which the collision integrals are tabulated, to experimental and/or accurate theoretical calculations for each of these states. The collision integrals are applied to calculate the diffusion coefficient, viscosity, and translational contribution to the thermal conductivity of monatomic carbon at 1-atm pressure from 1000 K to 25,000 K. Because of ablation injection, monatomic carbon is an important flow field constituent of ablative flow during planetary entry, and knowledge of the transport properties for carbon species is required for calculating the flow field properties and surface heating.

MAJS: /•ABLATIVE MATERIALS/•CARBON/•MONATOMIC GASES/•WORSE POTENTIAL/•TRANSPORT PROPERTIES

78A40838  
UTTL: Carbon vaporization into a nonequilibrium, stagnation-point boundary layer  
AUTH: A/SUZUKI, T. CORP. National Aeronautics and Space Administration, Ames Research Center, Moffett Field, Calif.

ABS: AIAA Journal, vol. 16, July 1978, p. 754-756. The heat transfer to the stagnation point of an ablating carbonaceous heat shield, where both the gas-phase boundary layer and the heterogeneous surface reactions are not in chemical equilibrium, is examined. Specifically, the nonequilibrium changes in the mass fraction profiles of carbon species calculated for frozen flow are studied. A set of equations describing the steady-state, nonequilibrium laminar boundary layer in the axisymmetric stagnation region, over an ablating graphite surface, is solved, with allowance for the effects of finite rate of carbon vaporization.

MAJS: /•ABLATION/•CARBON/•HEAT SHIELDING/•LAMINAR BOUNDARY LAYER/•SPACECRAFT SHIELDING/•STAGNATION POINT

78A37273

UTTL: Carbonaceous materials subjected to extreme heating - A comparison of numerical simulation and experiments  
AUTH: A/DAVY, W. C.; B/HERIES, G. P.; C/LUNDELL, J. H.; D/DICKEY, R. R. CORP: National Aeronautics and Space Administration, Ares Research Center, Moffett Field, Calif.

American Institute of Aeronautics and Astronautics and American Society of Mechanical Engineers.  
Thermophysics and Heat Transfer Conference, 2nd, Palo Alto, Calif., May 24-26, 1978. AIAA 9 p.

ABS: The ablation of carbonaceous materials in a hydrogen-helium stream has been simulated using a charring materials ablator computer code. These results are compared with the first ablation data to be obtained from the Ames-NASA Giant Planet Pilot Facility. Test stream diagnostics and ablation effects on convective and radiative heat transfer are discussed since these parameters constitute important input data to the numerical simulation. Graphite ablation was predicted to within 10 to 20% and carbon-phenolic somewhat less accurately.

MAJS: /-ABLATIVE MATERIALS/-COMPUTERIZED SIMULATION/-HEAT SHIELDING/-HELIUM HYDROGEN ATMOSPHERES/-PYROLYTIC GRAPHITE/-THERMAL SIMULATION

78A37271

UTTL: An irreversible thermodynamics model for graphite sublimation in intense radiation environments

AUTH: A/LAKER, R. L.  
American Institute of Aeronautics and Astronautics and American Society of Mechanical Engineers.  
Thermophysics and Heat Transfer Conference, 2nd, Palo Alto, Calif., May 24-26, 1978. AIAA 10 p.

ABS: A model for the phase change behavior of graphite when exposed to a high external radiation heat flux has been developed in order to examine solid-gas nonequilibrium effects. The usual Knudsen-Langmuir type model is extended to one which allows both pressure and temperature discontinuities at the ablating surface. Calculated results indicate a relatively constant effective heat of ablation. However, major uncertainties are shown to remain regarding individual carbon species concentrations and the input energy required for melting. A unique feature of the irreversible thermodynamics model is the prediction of gas phase supersaturation when JANNAF thermochemical data is utilized.

MAJS: /-ABLATION/-GRAPHITE/-HEAT SHIELDING/-IRREVERSIBLE PROCESSES/-NONEQUILIBRIUM THERMODYNAMICS/-SUBLIMATION /-THERMAL PROTECTION

78A36C25

UTTL: Radiative flux penetration through a blown shock layer for Jupiter entry conditions  
AUTH: A/MOSS, J. N.; B/JONES, J. J.; C/SIMMONDS, A. L. CORP: National Aeronautics and Space Administration, Langley Research Center, Langley Station, Va.

American Institute of Aeronautics and Astronautics and American Society of Mechanical Engineers.  
Thermophysics and Heat Transfer Conference, 2nd, Palo Alto, Calif., May 24-26, 1978. AIAA 12 p.

ABS: A study is made of the radiative blockage due to carbonaceous ablation injection for a probe entering the Jupiter atmosphere. This is accomplished by calculating the stagnation-point blockage factors for three entry trajectories that account for variations in probe configuration, atmospheric gas composition, and entry conditions. The radiative blockage within the relatively cool ablation layer is shown to be large and to be primarily dependent upon the absorption of the C2 and C3 species. The C3 absorption is significant, particularly when the new experimental data for C3 spectral absorption properties are used. Also, the stagnation-point radiative blockage factors are shown to correlate well in terms of the no-injection radiative heating rates for various entry conditions.

MAJS: /-ABLATION/-ATMOSPHERIC ENTRY/-JUPITER ATMOSPHERE/-JUPITER PROBES/-RADIATION SHIELDING/-RADIATIVE HEAT TRANSFER/-SHOCK LAYERS

78A36C23

UTTL: Some effects of ablation on transport properties in the Jovian atmosphere  
AUTH: A/BIGLI, L. CORP: Missouri Univ., Rolla.

American Institute of Aeronautics and Astronautics and American Society of Mechanical Engineers.  
Thermophysics and Heat Transfer Conference, 2nd, Palo Alto, Calif., May 24-26, 1978. AIAA 7 p.

ABS: In this paper the transport properties at the inner and outer boundary for mixing between ablation products and a Jovian-like atmosphere are calculated. The dominant species at these boundaries are C, H, O, He, H<sub>2</sub>, and e. Accurate potential energy curves are obtained for the fifteen possible two-body interactions among these species by fitting good semiempirical potentials for which transport collision cross sections have been tabulated to accurate experimental and theoretical information. Results are obtained for the viscosity and translational thermal conductivity of the pure species and the binary diffusion coefficients from 1000 Å to 25,000 K. In addition, the mixture translational thermal conductivity and viscosity are calculated at the inner



and outer mixing boundaries. This information is required for calculating flowfield properties and surface heating. The most important conclusion is that the translational thermal conductivity is substantially lower at the inner mixing boundary than it is at the outer mixing boundary.

MAJS: /\*ABLATION/\*ATMOSPHERIC ENTRY/\*JUPITER ATMOSPHERE/\* KINETIC THEORY/\*TRANSPORT PROPERTIES

78A35994

UTTL: Integral solutions of ablation problems with time-dependent heat flux

AUTH: AIZIEN, T. F.

American Institute of Aeronautics and Astronautics and American Society of Mechanical Engineers, Thermophysics and Heat Transfer Conference, 2nd, Palo Alto, Calif., May 24-26, 1978, AIAA 16 p. Navy-supported research.

ABS: Approximate solutions are presented for the one-dimensional transient ablation problem with two specific forms of the time-dependent boundary heat flux, i.e.,  $q(t)$  approximately equal to  $t \exp m$  and  $q(t)$  approximately equal to  $\exp t$ , based on Landau's idealized ablation model. The solutions are obtained using the new simple integral procedure employed earlier by the author for the solution of boundary-layer flow problems and transient heat conduction problems alike. These solutions are compared with the corresponding solutions by the classical heat balance integral method. Some special features of the solutions are noted.

MAJS: /\*ABLATION/\*HEAT FLUX/\*THERMAL BOUNDARY LAYER/\* TRANSIENT HEATING

78A35993

UTTL: A Monte Carlo statistical uncertainty analysis method for nosetip recession predictions

AUTH: A/SHERMAN, M. M.; B/SWATH, D. H.

American Institute of Aeronautics and Astronautics and American Society of Mechanical Engineers, Thermophysics and Heat Transfer Conference, 2nd, Palo Alto, Calif., May 24-26, 1978, AIAA 9 p.

ABS: A Monte Carlo statistical technique has been developed for obtaining quantitative estimates of the uncertainties associated with nosetip recession predictions in clear air and in erosive weather environments. Several key parameters in the analytical ablation and erosion models are identified and uncertainty bands are assigned to each parameter based on a review of the supporting data bases. The Monte Carlo technique was incorporated in a nosetip ablation/erosion computer program and sample

calculations were performed to illustrate the use of the method. The technique is shown to provide a rapid, accurate method for defining rational design safety factors and for evaluating the relative importance of individual parameters in the nosetip recession models. /\*ABLATION/\*EROSION/\*MONTE CARLO METHOD/\*NOSE CONES/\* PERFORMANCE PREDICTION/\*STATISTICAL ANALYSIS

78A35940

UTTL: An experimental study on the transient thermal response of ablating axisymmetric bodies

AUTH: A/KARASHIMA, K.; B/ARAI, N.; C/SAITO, K.

Japan Society for Aeronautical and Space Sciences, Transactions, vol. 20, Feb. 1978, p. 216-224.

ABS: Measurements made on changes in body shape and internal temperature distribution with time of Teflon hemisphere-cylinder models are used to evaluate the transient thermal response of ablating axisymmetric bodies. Attention is given to the effect of phase transitions. It is noted that a steady rate of ablation is achieved quickly at the stagnation point, and that the local ablation rate downstream changes slowly with time. A large temperature gradient is observed in the gel layer next to the ablating surface. In addition, the internal temperature of the body tends to rise after the surface temperature becomes constant, due to the effects of gel layer growth and radial heat conduction. A high enthalpy (1200 C) hypersonic wind tunnel with a conical nozzle (8.4 mm throat diameter, 60 mm exit diameter, and 10 deg semiexpansion angle) and an air exhaust system was used in the tests.

MAJS: /\*ABLATIVE MATERIALS/\*AEROTHERMODYNAMICS/\*REENTRY SHIELDING/\*TEMPERATURE EFFECTS/\*TRANSIENT HEATING/\* WIND TUNNEL TESTS

78A35912

UTTL: Numerical solution of the ablation equation

AUTH: A/ZNAMENSKIY, V. V.

Akademika Nauk SSSR, Izvestiya, Mekhanika Zhidkosti i Gaza, Mar.-Apr. 1978, p. 147-154. In Russian.

ABS: In the present paper, Murzinov's (1965) equation is analyzed which describes ablation due to convective aerodynamic heating on the simplifying assumptions that the pressure depends only on the local angle of slope of the surface and that the local similarity concept may be applied to the heat fluxes. Some mathematical aspects of solving this equation numerically are discussed. A proof for the instability of explicit finite-difference schemes at the stagnation point is obtained, and a stable explicit-implicit scheme is proposed.

MAJS: /\*ABLATION/\*AERODYNAMIC HEATING/\*CONVECTIVE HEAT  
TRANSFER/\*MASS TRANSFER/\*NUMERICAL ANALYSIS/\*PANT  
PROGRAM

78A35911

UTTL: Stable shape of bodies disintegrating due to  
aerodynamic heating

AUTH: A/VORONKIN, V. G.; B/LUNEV, V. V.; C/NIKULIN, A. N.  
Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i  
Gaza, Mar.-Apr. 1978, p. 138-146. In Russian.

ABS: In the present paper, solutions to an equation  
describing the stable shape of ablating bodies are  
obtained using a simplified formulation of the problem  
(assuming a local law for the pressure and for the  
heat flux distribution). It is shown that this problem  
does not possess a solution in the class of smooth  
functions and that the stable contour of the body must  
have a corner point in the case of purely laminar or  
turbulent heat transfer, and up to three corner points  
if the transition region is taken into consideration.  
Representative bodies of this type are composed of a  
blunted nose and an adjoining (at an angular point)  
lateral surface with a small but precisely specified  
angle of slope.

MAJS: /\*ABLATION/\*ABLATIVE NOSE CONES/\*AERODYNAMIC HEATING/\*  
PANT PROGRAM

78A34506

UTTL: Analysis of ablation debris from natural and  
artificial iron meteorites

AUTH: A/BLANCHARD, M. B.; B/DAVIS, A. S. CORP: National  
Aeronautics and Space Administration, Ames Research  
Center, Moffett Field, Calif.; San Jose State Univ.,  
Calif.

Journal of Geophysical Research, vol. 83, Apr. 10,  
1978, p. 1793-1808.

ABS: Iron and nickel-iron samples subjected to treatment by  
an arc-heated plasma of ionized air were used to model  
meteor ablation. The artificial ablation debris and  
fusion crusts were compared to the fusion crusts of  
three natural iron meteorites and to magnetic  
spherules from deep-sea manganese nodules. An outer  
discontinuous crust of magnetite and wuestite,  
followed by an unoxidized metallic zone, was observed  
in the artificially produced samples. Fractionation of  
less volatile elements was also noted.

MAJS: /\*ABLATION/\*IRON METEORITES/\*METEORITIC COMPOSITION/\*  
METEORITIC MICROSTRUCTURES

78A32335

UTTL: Experimental studies of the AFFDL flared-nozzle  
ablation simulation technique

AUTH: A/SCAGGS, N. E.; B/STETSON, K. F.  
In: Aerodynamic Testing Conference, 10th, San Diego,  
Calif., April 19-21, 1978, Technical Papers,  
(A78-32326 12-09) New York, American Institute of  
Aeronautics and Astronautics, Inc., 1978, p. 53-63.

ABS: A test program designed to further study the flared  
nozzle ablation simulation technique utilized in the  
50-Megawatt facility of the Air Force Flight Dynamics  
Laboratory (AFFDL) was conducted in a 20-in.  
hypersonic wind tunnel and the AFFDL Mach 6  
high-Reynolds number facility. The 20-in. tunnel was  
equipped with a flared nozzle geometrically scaled  
from the nozzle installed in the AFFDL reentry  
nose-tip test leg. A similarly scaled sphere-cone  
model was tested in the flow field produced by this  
nozzle. Pressure and heat transfer rate distributions  
were measured and ablation characteristics of models  
fabricated out of camphor were recorded on film. A  
duplicate test program was conducted in the parallel  
flow field produced by the Mach 6 contoured nozzle.  
The results of the two series of tests substantiate  
that a low supersonic flared nozzle flow can closely  
duplicate the hypersonic pressure and heat transfer  
distributions over the nose region of a blunt body.

MAJS: /\*ABLATION/\*FLIGHT SIMULATION/\*HYPERSONIC WIND TUNNELS  
/\*NOZZLE FLOW/\*REENTRY EFFECTS/\*TEST FACILITIES/\*WIND  
TUNNEL TESTS

78A29110

UTTL: Certain characteristics and solutions of the ablation  
equation

AUTH: A/LUNEV, V. V.  
(Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i  
Gaza, May-June 1977, p. 95-102.) Fluid Dynamics, vol.  
12, no. 3, Jan. 1978, p. 421-427. Translation.  
ABS: (For abstract see Issue 18, p. 3039. Accession no.  
A77-35685)

MAJS: /\*ABLATION/\*AERODYNAMIC HEATING/\*AEROTHERMODYNAMICS/\*  
CONVECTIVE HEAT TRANSFER/\*SHOCK WAVE INTERACTION/\*  
SURFACE GEOMETRY

78A29658

UTTL: Development of carbon-reinforced composites

AUTH: A/DEVCUGE, M. C.  
(Colloque sur les Matériaux Nouveaux, Bordeaux,  
France, Apr. 20-22, 1977.) L'Aéronautique et  
l'Astronautique, no. 68, 1978, p. 17-27. In French.  
ABS: The fabrication of carbon-carbon composites used as  
ablation materials in high-temperature nozzles is

described. The composites, called 'rigidimers', are composed of a textile reinforcement in a resin matrix which contains high levels of carbon and various charges; the preparation of the reinforcement, generally in tissue, filter, or fiber form, includes exposure to high temperatures, and the matrix is made from coke or pyrographite. Theoretically based explanations of the properties of these materials have not yet been developed. Preparation of the constituent materials and cutting, molding, and impregnation techniques are described. Properties of different carbon-carbon composites are reported.

MAJS: /\*ABLATIVE MATERIALS/\*CARBON-CARBON COMPOSITES/\*NOZZLE DESIGN

78A27457

UTTL: Application of the method of generalized diffusion coefficients to the solution of adjoint problems

AUTH: A/GLEBOV, G. A.  
(Vsesoyuznyi Seminar po Obratnym i Sopriazhennym Zadacham Teploobmena, 2nd, Moscow, USSR, Oct. 19-21, 1976.) Inzhenerno-Fizicheskii Zhurnal, vol. 33, Dec. 1977, p. 1001-1006. In Russian.

ABS: Calculation of the heating and ablation of heat-shield materials in high-temperature gas flows involves the solution of a system consisting of differential boundary layer equations and an unsteady heat equation for a solid body. In the present paper, the flow of a chemically reacting mixture at the forward stagnation point of a body made of graphite is analyzed, and a numerical method of solving the corresponding system of equations is proposed.

MAJS: /\*ABLATIVE MATERIALS/\*AERODYNAMIC HEATING/\*DIFFUSION COEFFICIENT/\*GRAPHITE/\*HEAT SHIELDING/\*MATHEMATICAL MODELS

78A25206

UTTL: A digital data analysis technique for an ultrasonic ablation gauge

AUTH: A/BEATTIE, A. G.  
In: Materials and processes - In service performance: Proceedings of the Ninth National Technical Conference, Atlanta, Ga., October 4-6, 1977. (A78-25176 C9-23) Azusa, Calif., Society for the Advancement of Material and Process Engineering, 1977, p. 432-444.

ABS: A description is presented of a method of analysis for reducing ultrasonic ablation gauge data by means of digital techniques. The method is based on the electronic digitization of the data and the use of a cross correlation function to determine the position in time of the echo. The considered procedure provides

reasonable estimates of the echo position even in the presence of severe background noise. The method of data analysis could be improved by modifying the ultrasonic ablation gauge. The wider the frequency bandwidth of the noise, the better a cross correlation technique will work to eliminate the effects of the noise. The electronic bandwidth should, therefore, be as wide as possible within the limits imposed by the telemetry system.

MAJS: /\*ABLATION/DIGITAL TECHNIQUES/\*MEASURING INSTRUMENTS /\*ULTRASONIC TESTS

78A22752

UTTL: Model of the Rayleigh-Taylor stability of an ablating fluid

AUTH: A/CATTI, P. J.  
Physics of Fluids, vol. 21, Jan. 1978, p. 30-33.  
Research supported by the University of Rochester.  
ABS: An incompressible and inviscid model for the Rayleigh-Taylor stability of an ablating fluid in the absence of convection is presented and solved analytically for boundary conditions appropriate to laser produced plasmas. The wavenumbers perpendicular to the density gradient of scale length are found to be relatively insensitive to ablative stabilization for the most unstable radial eigenmodes.

MAJS: /\*ABLATION/\*INCOMPRESSIBLE FLOW/\*INVISCID FLOW/\*LASER PLASMAS/\*MATHEMATICAL MODELS/\*TAYLOR INSTABILITY

78A22583

UTTL: The response of heat-shield materials to intense laser radiation

AUTH: A/LUNCELL, J. H.; B/DICKEY, R. R. CORP: National Aeronautics and Space Administration, Ames Research Center, Moffett Field, Calif.  
American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 16th, Huntsville, Ala., Jan. 16-18, 1978, 9 p.

ABS: Experimental results for the response of AlJ graphite, Carbide 10C, and carbon phenolic to intense continuous-wave laser radiation are presented. Both penetration and mass-loss test techniques are used and compared. The results are also compared with a simple ablation theory applicable to laser irradiation. Reasons for the disparity between experiment and theory, and applicability of the results to other heating situations, such as planetary entry, are discussed.

MAJS: /\*ABLATION/\*CARBON FIBER REINFORCED PLASTICS/\*CARBON-CARBON COMPOSITES/\*HEAT SHIELDING/\*LASER OUTPUTS/\*PYROLYTIC GRAPHITE/\*THERMOCHEMICAL PROPERTIES

78A21267

UTTL: Method for reducing the ablation of bodies in supersonic plasma flow

AUTH: A/SULTANOV, M. A.  
Zhurnal Tekhnicheskoi Fiziki, vol. 47, Oct. 1977, p. 2213-2216. In Russian.

ABS: Experiments were performed in a gas discharge chamber at atmospheric pressure to study ablating supersonic ( $M = 4$ ) plasma flow past steel plates connected by copper wire to a large grounded metallic body. Photographic visualization was used to study shock waves of different intensity and size at the plate surfaces as well as the erosion characteristics at the surfaces. Data analysis shows that the supersonic-plasma ablation of the plate surfaces is closely associated with the presence of an electron-trapping layer and a mechanism of electronic heat transfer.

MAJS: /\*ABLATION/\*ATMOSPHERIC ENTRY SIMULATION/\*CONDUCTIVE HEAT TRANSFER/\*MAGNETOHYDRODYNAMIC FLOW/\*PLASMA SPRAYING/\*SUPERSONIC FLOW

78A20760

UTTL: Thermochemical ablation of materials from normal impingement of solid propellant rocket motor exhaust

AUTH: A/MCGEE, G. R.; B/ANDERSON, L. P.; JR.; C/LEWIS, C. H.; D/MURRAY, A. L.  
American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 16th, Huntsville, Ala., Jan. 16-18, 1978, 8 p.

ABS: The thermochemical response of three ablative materials was evaluated for protecting a plenum exhaust system from the environments due to the firings of two different solid propellant motors. The response of silica phenolic and two asbestos phenolic materials was studied for the cases of a single step (booster only) rocket motor and a two step (booster and sustainer) rocket motor being fired at normal impingement onto two-dimensional infinite flat plates of the materials. Results are presented for both the gas flow predictions and the material ablation.

MAJS: /\*ABLATIVE MATERIALS/\*FLAT PLATES/\*JET IMPINGEMENT/\*ROCKET EXHAUST/\*SOLID PROPELLANT ROCKET ENGINES/\*THERMOCHEMICAL PROPERTIES

78A20750

UTTL: Supersonic flow over ablated nosetips using an unsteady, implicit numerical procedure

AUTH: A/KUTLER, P.; B/CHAKRAVARTHY, S. R.; C/LUMBARD, C. K. CORP.; National Aeronautics and Space Administration, Ames Research Center, Moffett Field, Calif.; Iowa State Univ. of Science and Technology.

Ames.; Lockheed Missiles and Space Co.; Palo Alto, Calif.

American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 16th, Huntsville, Ala., Jan. 16-18, 1978, 14 p. Research supported by the Iowa State University of Science and Technology and NASA.

ABS: The axisymmetric supersonic flow over passive, that is, nonablating, indented nosetips of reentry vehicles is determined using an unsteady implicit numerical algorithm which solves either the inviscid Euler equations or the 'thin-layer' Navier-Stokes equations. A nonorthogonal independent variable transformation is used to map the distorted physical region, containing multiple zones of embedded subsonic flow into a rectangular computational domain at whose boundaries the required permeable or impermeable boundary conditions are simulated. Use of the implicit algorithm results in faster convergence to the steady state because of a larger allowable time step over conventional explicit schemes. The numerical results obtained compare favorably with existing experimental data for very mildly and severely indented blunt nosetips.

MAJS: /\*ABLATION/\*AXISYMMETRIC FLOW/\*NOSES (FOREBODIES)/\*NUMERICAL ANALYSIS/\*REENTRY VEHICLES/\*SUPERSONIC FLOW

78A17390

UTTL: In-flight measurements of thermal response of a carbon phenolic heatshield

AUTH: A/WRICHT, G. F.; JR.; B/MCBRIDE, D. D.  
In: International Instrumentation Symposium, 23rd, Las Vegas, Nev., May 1-5, 1977, Proceedings, (A78-17351 05-35) Pittsburgh, Pa., Instrument Society of America, 1977, p. 407-410.

ABS: Thermal sensors were designed and incorporated for heatshield measurements of the near-surface and in-depth thermal response of carbon phenolic in a reentry flight environment. The sensors proved sensitive enough to detect boundary layer transition to within 0.1 second. Calculations of the expected thermal response are compared with experimental data and discussed with reference to reasons for agreement or discrepancies. Construction and installation details of the sensors are also presented.

MAJS: /\*ABLATIVE MATERIALS/\*FLIGHT TESTS/\*HEAT SHIELDING/\*PHENOLIC RESINS/\*REENTRY VEHICLES/\*TEMPERATURE SENSORS

78A17370

UTTL: Automated calibration of a radioactive ablation sensor  
AUTH: A/ARMINI, A. J.; B/BUNKER, S. N.

In: International Instrumentation Symposium, 23rd, Las Vegas, Nev., May 1-5, 1977. Proceedings. (A78-17351 05-35) Pittsburgh, Pa.: Instrument Society of America, 1977. p. 247-252. USAF-sponsored research.

ABS: A device has been developed for the automated calibration of a radioactive ablation sensor. It spatially measures line source radioactivity in a multiray nose-tip ablation sensor. The design provides fast gamma ray counting speed, high accuracy level, and operational flexibility. Dual high efficiency germanium detectors with large acceptance collimators are used to achieve speed. Including all significant nonstatistical error sources, accuracy is typically 1.50%. Corrections are made for factors including background, trace impurity activation, known carbon density variations, source wander, and finite collimator geometry. The configuration utilizes a microcomputer for the mechanical control of nose-tip positioning, and to provide an on-line data analysis. A typical ray having a spatial resolution better than 2 mm full wave at 0.1 maximum may be scanned in 1-2 hours.

MAJS: /\*ABLATION/\*CALIBRATING/\*NUMERICAL CONTROL/\*RADIATION COUNTERS

78A17356

UTTL: Scintillator/Photomultiplier Ablation Detector /SPAD/ for use in reentry vehicles

AUTH: A/FITZGERALD, W. A., JR.; B/MITTON, A. W., JR.  
In: International Instrumentation Symposium, 23rd, Las Vegas, Nev., May 1-5, 1977. Proceedings. (A78-17351 05-35) Pittsburgh, Pa.: Instrument Society of America, 1977. p. 41-50. Research supported by the Independent Research and Development Program and U.S. Air Force.

ABS: The Scintillation/Photomultiplier Ablation Detector (SPAD), a flight-qualified radiation detector, has been developed for measuring the shape change and ablation characteristics of various reentry vehicle nosetip materials. The removal of many implanted radioactive line sources can be monitored through collimation holes by an equal number of SPADs. The key design features include high gamma ray detection efficiency, small detector cross sectional area, sensor placement flexibility, avoidance of mechanical isolation systems, and system reliability. This paper describes the design, performance characteristics and qualification testing of SPAD.

MAJS: /\*ABLATION/\*ABLATIVE NOSE CONES/\*PHOTOMULTIPLIER TUBES /\*REENTRY VEHICLES/\*SCINTILLATION COUNTERS

77A49729

UTTL: Properties of BN-3DX, a 3-dimensional reinforced boron nitride composite

AUTH: A/PLACE, T. M.  
In: Symposium on Electromagnetic Windows, 13th, Atlanta, Ga., September 21-23, 1976. Proceedings. (A77-49726 23-32) Atlanta, Ga.: Georgia Institute of Technology, 1977. p. 17-22. USAF-supported research.

ABS: A three-dimensional reinforced boron nitride composite for high temperature reentry antenna-window applications is characterized. The composite has an ablative recession behavior similar to carbon phenolic heat-shield materials and intrinsic boron nitride dielectric properties in an ablative environment. The paper describes the three-dimensional woven construction, gives attention to processing, and presents results of mechanical (tensile, compression and flexure) and thermophysical (thermal conductivity and expansion) measurements.

MAJS: /\*ABLATIVE MATERIALS/\*BORON NITRIDES/\*BORON REINFORCED MATERIALS/\*MECHANICAL PROPERTIES/\*THERMOPHYSICAL PROPERTIES/\*THREE DIMENSIONAL COMPOSITES

77A47044

UTTL: Low-cycle fatigue of two austenitic alloys in hydrogen gas and air at elevated temperatures

AUTH: A/JASKE, C. E.; B/RICE, R. C. CORP: Battelle Columbus Labs., Ohio.

In: Symposium on Creep-Fatigue Interaction, New York, N.Y., December 5-10, 1976. Proceedings. (A77-47042 22-26) New York. American Society of Mechanical Engineers, 1976. p. 101-128. Research supported by the Aerojet Nuclear Systems Co.;

ABS: The low-cycle fatigue resistance of type 347 stainless steel and Hastelloy Alloy X was evaluated in constant-amplitude, strain-controlled fatigue tests conducted under continuous negative strain cycling at a constant strain rate of 0.001 per sec and at total axial strain ranges of 1.5, 3.0, and 5.0 percent in both hydrogen gas and laboratory air environments in the temperature range 538-871 C. Elevated-temperature, compressive-strain hold-time experiments were also conducted. In hydrogen, the cyclic stress-strain behavior of both materials at 538 C was characterized by appreciable cyclic hardening at all strain ranges. At 871 C neither material hardened significantly. In fact, at 5% strain range, 347 steel showed continuous cyclic softening until failure. The fatigue resistance of 347 steel was slightly higher than that of Alloy X at all temperatures and strain ranges. Ten-minute compressive hold time experiments at 760 and 871 C resulted in increased fatigue lives for 347 steel and decreased fatigue lives for Alloy X. Both alloys

showed slightly lower fatigue resistance in air than in hydrogen. Some fractographic and metallographic results are also given.

MAJS: /\*ABLATIVE MATERIALS/\*AUSTENITIC STAINLESS STEELS/\* FATIGUE LIFE/\*FATIGUE TESTS/\*HASTELLOY (TRADEMARK)/\* STRESS CYCLES

77A46857

UTTL: Aerothermal and rain erosion behavior of selected candidate plastic radome materials in Mach 5 sled tests

AUTH: A/LEITSON, K. M.: B/BURLESON, W. G.: C/ORMSBY, P. A. ASME, SAE, AIAA, ASMA, and AICHE, Intersociety Conference on Environmental Systems, 7th, San Francisco, Calif., July 11-14, 1977, ASME 9 p.

ABS: The aerothermal and rain erosion behavior of six plastics has been investigated at a velocity of Mach 5 in sled tests at Holloman Air Force Base. The rain erosion behavior of plastics in Mach 5 sled tests is complicated by the loss of material due to aerothermal ablation because surface temperatures exceed the decomposition or phase-change temperature of the plastics. Thus, to distinguish the loss of material caused by thermal effects from that caused by rain, one test without rain and one test through simulated rain were conducted. Materials tested were Avcoat 8327, Avcoat 9023, Duroid 5650, Duroid 5870, polyimide-glass laminate, and Teflon.

MAJS: /\*ABLATION/\*HYPERSONIC TEST APPARATUS/\*PLASTICS/\* RADOME MATERIALS/\*RAIN EROSION/\*ROCKET PROPELLED SLEDS

77A40175

UTTL: A model for the ablation rate of a solid hydrogen pellet in a plasma

AUTH: A/PAKKS, P. B.: B/TURNBULL, R. J.: C/FOSTER, C. A. Nuclear Fusion, vol. 17, June 1977, p. 539-556.

ABS: It is shown that the ablation of a solid hydrogen pellet subject to a plasma is likely to produce a quasi-steady dense neutral gas cloud. The total integrated density of the cloud is such that the plasma electrons lose essentially all their energy in the cloud. The electron energy flux is degraded by inelastic collisions and elastic backscattering with the neutral molecules, providing local heating and acceleration of the neutral gas. Only a small fraction of the energy flux reaches the surface of the pellet, raising the pellet's surface temperature to a point where the energy lost through vaporization is in balance with the energy lost through vaporization. The integrated neutral gas cloud density. The scaling laws

derived from the model indicate that the pellet lifetime varies as the  $-1.71$  power of electron temperature, the  $-1/3$  power of plasma density, and the  $5/3$  power of initial pellet radius. Good agreement is found between this model and the ORMAK pellet-injection experiment.

MAJS: /\*ABLATIVE MATERIALS/\*FUEL CAPSULES/\*NUCLEAR FUELS/\* PELLETS/\*TOKAMAK DEVICES

77A39510

UTTL: The effect of ablation injection on radiative and convective heating

AUTH: A/ROSS, J. N. CORP: National Aeronautics and Space Administration, Langley Research Center, Langley Station, Va.

IN: Recent advances in engineering science, Volume 8, (A77-39904 18-31) Boston, Mass., Scientific Publishers, Inc., 1977, p. 143-150.

ABS: A viscous shock-layer analysis for calculating high energy equilibrium flow fields about blunt axisymmetric bodies is applied to the problem of massive ablation injection with radiation transport. A nongray radiation model is used that accounts for both line and continuum radiation. The solution method is direct and provides both stagnation and downstream solutions. Results for shock heated air show that phenolic-nylon injection is substantially more effective in reducing the wall radiant flux than air injection. Also, for large included body angles, the wall radiative flux and the coupled phenolic-nylon injection rate do not continue to decrease with increasing distance downstream.

MAJS: /\*ABLATION/\*ATMOSPHERIC ENTRY/\*CONVECTIVE HEAT TRANSFER/\*FLOW DISTRIBUTION/\*GAS INJECTION/\*RADIATIVE HEAT TRANSFER

77A39585

UTTL: Some properties and solutions of the ablation equation

AUTH: A/LURIEV, V. V. Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza, May-June 1977, p. 95-102. In Russian.

ABS: The characteristic strongly nonlinear properties of a first-order integrodifferential ablation equation are described for two-dimensional problems. A solution of this equation is obtained at the corner points of an uneven initial contour. It is shown that the solution describes three types of integrated surface: one, where the corner point is retained; one, where the corner point is 'smeared out'; and a solution of mixed type.

MAJS: /\*ABLATION/\*AERODYNAMIC HEATING/\*AEROTHERMODYNAMICS/\* CONVECTIVE HEAT TRANSFER/\*SHOCK WAVE INTERACTION/\*

## SURFACE GEOMETRY

77A37567

UTTL: Intumescent-ablators as improved thermal protection materials  
AUTH: A/SAWKO, P. M.; B/RICCITIELLO, S. R. CORP: National Aeronautics and Space Administration, Ames Research Center, Moffett Field, Calif.  
(American Chemical Society, Meeting, New Orleans, La., Mar. 20-25, 1977.) Journal of Coatings Technology, vol. 49, Apr. 1977, p. 38-43.

ABS: Nitroaromatic amine-based intumescent coatings were improved with regard to their thermal protection ability by adding endothermic decomposing fillers with endotherms at or near the exothermic reaction of the intumescent agent, since the effectiveness of the intumescent coatings without fillers is reduced by the exothermic behavior of the coatings during thermal activation. Fillers were dispersed directly in the base coating. Potassium fluoborate, ammonium fluoborate, zinc borate, and ammonium oxalate function as endothermic ablative materials at specific temperature regions, and also enhance the char formation during the intumescent process.

MAJS: /\*ABLATIVE MATERIALS/\*ENDOTHERMIC REACTIONS/\*FILLERS/\*FIRE FIGHTING/\*THERMAL CONTROL COATINGS/\*THERMAL PROTECTION

77A37820

UTTL: Structure and scaling laws of laser-driven ablative implosions  
AUTH: A/GITCHER, S. J.; B/MORSE, R. L.; C/NEWBERGER, B. S. Physics of Fluids, vol. 20, Feb. 1977, p. 234-238.  
ERDA-implosion research.

ABS: A stationary flow model of spherical ablation processes is proposed for studying the dynamics of spherical implosions. Scaling laws derived from this model show the dependence of ablation pressure and mass flow rate on laser and pellet parameters. Those scaling laws indicate that the effect of optimum laser pulse shaping can, to some extent, be attained by increasing the Z number of the material on the outside of the pellet with increasing radius. Numerical solutions to the model equations indicate that the energy efficiency of the ablation process for driving spherical implosions varies inversely with laser wavelength for wavelengths not so large as to violate the stationary flow model.

MAJS: /\*ABLATION/\*IMPLOSIONS/\*LASER FUSION/\*MASS FLOW RATE/\*SCALING LAWS

77A37310

UTTL: Unsteady plasma acceleration with ablation of dielectric  
AUTH: A/GUSPCHIN, I. S.; B/POPOV, I. P.; C/SAVICHEV, V. V. (Fizika Plazmy, vol. 2, Sept.-Oct. 1976, p. 742-749.) Soviet Journal of Plasma Physics, vol. 2, Sept.-Oct. 1976, p. 413-417. Translation.  
ABS: (For abstract see issue 06, p. 911. Accession no. A77-18005)  
MAJS: /\*ABLATIVE MATERIALS/\*DIELECTRICS/\*NONUNIFORM PLASMAS/\*PLASMA ACCELERATION

77A37303

UTTL: Modelling of meteorite ablation process in laboratory conditions in supersonic plasma flow  
AUTH: A/SULTANOV, M. A. (Astronicheskii Vestnik, vol. 10, Oct.-Dec. 1976, p. 230-240.) Solar System Research, vol. 10, no. 4, Apr. 1977, p. 185-193. Translation.  
ABS: (For abstract see issue 07, p. 1144. Accession no. A77-2C516)  
MAJS: /\*ABLATION/\*ATMOSPHERIC ENTRY SIMULATION/\*BOUNDARY LAYER PLASMAS/\*MAGNETOHYDRODYNAMIC FLOW/\*METEOR TRAILS/\*SUPERSONIC FLOW

77A37289

UTTL: Experimental verification of the technique for measurement of ablation on the GASJET nose tip  
AUTH: A/DORCHOE, J. C.; B/BLACKSTOCK, T. A.; C/KEYES, J. W. CORP: Martin Marietta Aerospace, Orlando, Fla.; National Aeronautics and Space Administration, Langley Research Center, Langley Station, Va.  
American Institute of Aeronautics and Astronautics, Thermophysics Conference, 12th, Albuquerque, N. Mex., June 27-29, 1977, 7 p.

ABS: The GASJET nose tip is proposed to reduce the erosion at the apex of a missile nose flying at hypersonic speeds through a rain storm as it reenters the atmosphere. A forward facing sonic jet is directed through the tip introducing a secondary counter-flow which displaces the bow shock and blankets the tip with a protective layer of relatively cool gas. Wind tunnel experiments are described which proved the validity of measuring nose recession in flight by recording the pressure in the blast tube supplying the GASJET.

MAJS: /\*ABLATION/\*HYPERSONIC SPEED/\*MISSILE TESTS/\*NOSE CONES/\*RAIN EROSION/\*WIND TUNNEL TESTS

77A37288

UTTL: Influence of the partial optical transmittance on transient ablation of polytetrafluoroethylene  
AUTH: A/KINDLER, K.

American Institute of Aeronautics and Astronautics, Thermophysics Conference, 12th, Albuquerque, N. Mex., June 27-29, 1977, 9 p.

ABS: The paper calculates the transient ablation case of a semi-infinite one-dimensional body, taking into consideration the transparency of the amorphous zone of polytetrafluoroethylene. The results clarify some discrepancies in the relations between heat transfer blockage and mass transfer. Using the radiative heat transfer as source term in the Fourier equation in combination with the linear relationship between heat and mass transfer, we get results which are slightly different from those obtained with the exponential relationships. The effect of the radiative portion of heat transfer which is not absorbed at the body surface but within the amorphous zone is investigated with respect to the heat transfer blockage and the effective ablation heat.

MAJS: /-ABLATIVE MATERIALS/-POLYTETRAFLUOROETHYLENE/-TRANSIENT HEATING/-TRANSMITTANCE/-TRANSPARENCE

77A35304

UTTL: Orbiter Thermal Protection System Development  
AUTH: A/GREENSHIELDS, D. H. CORP: National Aeronautics and Space Administration, Lyndon B. Johnson Space Center, Houston, Tex.

In: Space Congress, 14th, Cocoa Beach, Fla., April 27-29, 1977, Proceedings. (A77-35301 15-12) Cocoa Beach, Fla.: Canaveral Council of Technical Societies, 1977, p. 1-28 to 1-42.

ABS: The development of the Space Shuttle Orbiter Thermal Protection System (TPS) is traced from concept definition through technical development, to final design and qualification for manned flight. A sufficiently detailed description of the TPS design is presented to support an in-depth discussion of the key issues encountered in conceptual design, materials development, and structural integration. Emphasis is placed on the unique combination of requirements which resulted in the use not only of revolutionary design concepts and materials, but also of unique design criteria, newly developed analysis, testing and manufacturing methods, and finally of an unconventional approach to system certification for operational flight. The conclusion is drawn that a significant advance in all areas of thermal protection system development has been achieved which results in a highly efficient, flexible, and cost-effective thermal protection system for the Orbiter of the Space

Shuttle System.  
MAJS: /-ABLATIVE MATERIALS/-REUSABLE HEAT SHIELDING/-SPACE SHUTTLE ORBITERS/-SPACECRAFT DESIGN/-THERMAL PROTECTION

77A27459

UTTL: Mechanical behavior of ablator/insulator materials  
AUTH: A/ADSLT, N. R.: 8/MAY, L. C.

In: Bicentennial of materials progress: Proceedings of the Twenty-first National Symposium and Exhibition, Los Angeles, Calif., April 6-8, 1976. (A77-27451 11-23) Azusa, Calif.: Society for the Advancement of Material and Process Engineering, 1976, p. 736-742. Research supported by the General Dynamics Corp. The mechanical behavior of several ablator/insulator materials for tanks used in space flight was measured over the temperature range from -423 F to 500 F. The need for elevated temperature data was due to aerodynamic heating during the reentry cycle of reusable tanks. Tension, compression, and shear tests were performed to fully characterize the mechanical behavior of these materials. From these tests, the strength (tension, compression, and shear) and elastic modulus were determined for each material at each test temperature. It is shown that strength and modulus are strongly related to the test temperature and can vary by two orders of magnitude in the temperature range observed. The epoxy-base materials appear to be less temperature-dependent than the elastomeric or polyurethane base materials.

MAJS: /-ABLATIVE MATERIALS/-CRYOGENIC FLUID STORAGE/-MECHANICAL PROPERTIES/-REUSABLE HEAT SHIELDING/-SPACECRAFT SHIELDING/-THERMAL INSULATION

77A27456

UTTL: Composite sprayable insulation for firewall, projectile and acoustical protection  
AUTH: A/MACCALOUS, J. W.

In: Bicentennial of materials progress: Proceedings of the Twenty-first National Symposium and Exhibition, Los Angeles, Calif., April 6-8, 1976. (A77-27451 11-23) Azusa, Calif.: Society for the Advancement of Material and Process Engineering, 1976, p. 704-711. The paper examines the possibility of using lightweight nonmetallic structural panels with fire-resistant ablative coatings as firewall protection in rapid transit cars, aircraft, and ships to isolate flame migration without releasing toxic fumes. Various combinations of potential panel materials are evaluated employing the elastomer-sprayable compound MA-25S as ablative firewall material. Specimen weights and backface temperature



rise under various surface temperature environments are presented. It is shown that composite firewall panels with ablative material coatings are feasible and that FRP (fiber reinforced isocyanurate)/aluminum substrate panels are most efficient, maintaining a backface temperature of 125 F at 750 F surface temperature. Honeycomb core/glass epoxy sandwich panels yield the least overall weight loss.

**MAJS:** /•ABLATIVE MATERIALS/•COMPOSITE MATERIALS/•FIREPROOFING/•PANELS/•PROTECTIVE COATINGS/•SPRAYED COATINGS

**77A26780**  
**UTTL:** Radiometric ablation sensor for measuring shape change of re-entry vehicle nosetips  
**AUTH:** A/ORPHAN, V. J.; B/GILAVEN, R. O.; C/VERBINSKI, V. V.; D/DOODY, H. L.  
 In: Advances in test measurement, Volume 13 - Proceedings of the Twenty-second International Instrumentation Symposium, San Diego, Calif., May 25-27, 1976. (A77-26776 11-35) Pittsburgh, Pa.: Instrument Society of America, 1976, p. 417-426. USAF-sponsored research.

**ABS:** A multiray radiometric sensor for measuring the in-flight ablation characteristics of a carbon-carbon reentry nosetip has been developed. Each of up to nine scintillators is collimated to view a line source of radioactivity. In 1982, produced by thermal neutron activation of InC fibers implanted in the tip material during fabrication. The CsI scintillators are each optically coupled by means of a bundle of flexible optical fibers to a digital proton counting tube that converts the photon output from the scintillator to an electrical signal. The key features of the sensor are compactness, insensitivity to acoustic noise, and high gamma ray detection efficiency.

**MAJS:** /•ABLATION/•ABLATIVE NOSE CONES/•CARBON-CARBON COMPOSITES/•RADIOMETERS/•REENTRY VEHICLES

**77A26780**  
**UTTL:** Effect of fabric orientation on the ablation performance of carbon phenolic  
**AUTH:** A/SHELDON, R. E.; B/RIGHT, G. F., JR.  
 In: Advances in test measurement, Volume 13 - Proceedings of the Twenty-second International Instrumentation Symposium, San Diego, Calif., May 25-27, 1976. (A77-26776 11-35) Pittsburgh, Pa.: Instrument Society of America, 1976, p. 23-32.  
**ABS:** Carbon phenolic has been in use as an ablator material for thermal protection systems for a number of years. Its characterization has been documented numerous times and has been incorporated in numerical ablation

codes. One aspect of the performance of this ablator material that has attracted recent attention is the variation in its performance with differing fabric orientation. Ablation tests of carbon phenolic with various fabric orientations were performed in a channel flow device powered by an arc plasma generator. It was found that fabric orientation has a major effect on the ablation performance of this material; one orientation in particular gave very poor results. Experimental procedure and results are presented here, along with comparisons of computed ablation performance and experimental data.

**MAJS:** /•ABLATIVE MATERIALS/•CARBON/•PHENOLIC RESINS/•REENTRY SHIELDING/•THERMAL PROTECTION

**77A26779**  
**UTTL:** The Rotating Ablating Sting Test Technique in the AFFDL RENT facility  
**AUTH:** A/GROENER, L. S.; B/STETSON, J. R.; C/LEGENORE, P. J.  
 In: Advances in test measurement, Volume 13 - Proceedings of the Twenty-second International Instrumentation Symposium, San Diego, Calif., May 25-27, 1976. (A77-26776 11-35) Pittsburgh, Pa.: Instrument Society of America, 1976, p. 15-21.

**ABS:** The major objective of the Rotating Ablating Sting Test Technique for reentry nosetip testing is to eliminate the effects of facility heating asymmetries by rotating the nosetip model at a sufficient angular velocity. The concept has been demonstrated for ramped and steady-state models and for rotation speeds between 350 and 2000 rpm. The materials tested included graphites, carbon-carbons, tungsten, and erosion-resistant composites.

**MAJS:** /•ABLATIVE MATERIALS/•ABLATIVE NOSE CONES/•COMPOSITE MATERIALS/•MATERIALS TESTS/•REENTRY EFFECTS/•ROTATING BODIES

**77A26752**  
**UTTL:** Calculations of the disintegration of the Lost City. Grant, and Pribram meteorites during earth-atmosphere entry  
**AUTH:** A/OVSIANNIKOV, V. M.  
 (Astronomicheskii Vestnik, vol. 10, July-Sept. 1976, p. 151-157.) Solar System Research, vol. 10, no. 3, Feb. 1977, p. 121-126. Translation.  
**ABS:** (For abstract see issue 03, p. 458, Accession no. A77-13069)  
**MAJS:** /•ABLATION/•AEROTHERMODYNAMICS/•ATMOSPHERIC ENTRY/•BLUNT BODIES/•METEORITES/•PRIBRAM METEORITE

77A25768

UTTL: Carbon-carbon microstructural characterization for use in modeling

AUTH: A/EITMAN, D. A.; B/BINDER, J. D.

In: Structures, Structural Dynamics and Materials Conference, 18th, March 21-23, 1977, and Aircraft Composites: The Emerging Methodology for Structural Assurance, San Diego, Calif., March 24, 25, 1977, Technical Papers, Volume A. (A77-25726 10-39) New York, American Institute of Aeronautics and Astronautics, Inc., 1977, p. 375-380.

ABS: Various types of microstructural characterization which can be obtained and methods of data reduction to make it usable for analytical modeling are discussed. The techniques available for characterizing the microstructure include the use of photomicrographs to make measurements of structural features.

crystallographic orientation and surface roughnesses scanning electron micrographs for low magnification observations requiring large depths of fields and for extreme magnifications beyond the limits of those obtainable using optical microscopy; and several techniques to measure total pore structure. These techniques are presented as well as some typical correlations currently being used for carbon-carbon ablation modeling.

MAJS: /•ABLATIVE MATERIALS/•CARBON-CARBON COMPOSITES/•DATA REDUCTION/ MATHEMATICAL MODELS/•MICROSTRUCTURE/•SURFACE ROUGHNESS EFFECTS

77A25767

UTTL: Reentry vehicle nosetip material screening tests - Series III

AUTH: A/LEGENDRE, P. J.; B/HEINONEN, E. W.; C/JUMPER, G. Y.; JR.; D/HOWEY, D. C.; E/ELLIOTT, M.

In: Structures, Structural Dynamics and Materials Conference, 18th, March 21-23, 1977, and Aircraft Composites: The Emerging Methodology for Structural Assurance, San Diego, Calif., March 24, 25, 1977, Technical Papers, Volume A. (A77-25726 10-39) New York, American Institute of Aeronautics and Astronautics, Inc., 1977, p. 370-374.

ABS: This paper presents the results of reentry vehicle nosetip materials screening tests which included 75 models and 21 materials. Of these models, four were graphite and 17 were carbon-carbons. The carbon-carbon weave geometries included 1-1-1, 1-1-3, 1-1-4, 1-1-5, 2-2-1, 2-2-3, 2-2-4, and 2-2-6 configurations plus a polar weave concept. There were at least five processing procedures involved in the carbon-carbon fabrication. The best materials were the 994 graphite and the 2-2-3 fine weave carbon-carbon.

MAJS: /•ABLATIVE MATERIALS/•ABLATIVE NOSE CONES/•CARBON-CARBON COMPOSITES/•REENTRY SHIELDING/•REENTRY VEHICLES

77A25754

UTTL: On the relation between material variability and surface roughness

AUTH: A/DIRLING, R. B.; JR.

In: Structures, Structural Dynamics and Materials Conference, 18th, March 21-23, 1977, and Aircraft Composites: The Emerging Methodology for Structural Assurance, San Diego, Calif., March 24, 25, 1977, Technical Papers, Volume A. (A77-25726 10-39) New York, American Institute of Aeronautics and Astronautics, Inc., 1977, p. 246-250.

ABS: The surface roughness developed during the high-temperature ablation of graphitic reentry vehicle nosetip materials significantly affects nosetip and vehicle aerodynamic performance through its influence on boundary layer transition and subsequent nose shaping events. This paper examines the relationship between roughness characteristics obtained from an optical measurement technique, observed transition variability, and measured material variability. A direct correlation between these quantities is indicated when the roughness data is corrected for the effect of measurement technique. Several material microstructural properties are identified which, if controlled through improved manufacturing techniques, may lead to improved reentry vehicle nosetip performance.

MAJS: /•ABLATIVE MATERIALS/•AERODYNAMIC HEATING/•GRAPHITE/•REENTRY PHYSICS/•SURFACE ROUGHNESS EFFECTS

77A25221

UTTL: Dependence of laser-driven compression efficiency on wavelength

AUTH: A/MCCORMY, R. L.; B/MORSE, R. L.

Physical Review Letters, vol. 38, Mar. 7, 1977, p. 544-547. ERCA-supported research.

ABS: Efficiency of ablative implosion of laser-heated pellets is estimated from numerical simulations based only on classical thermal conduction. An inverse dependence of overall nuclear-yield ratio on wavelength is indicated in the visible and near-infrared range.

MAJS: /•ABLATIVE MATERIALS/•IMPLOSIONS/•LASER FUSION/•NEAR INFRARED RADIATION/•NUMERICAL ANALYSIS/•THERMAL CONDUCTIVITY

77A22225

UTTL: Development of a steady-state shape change ablation code for the design of outer planet probes  
 AUTH: A/BREWER, R. A.; B/BRANT, D. N.; C/FOGAROLI, R. P. American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 15th, Los Angeles, Calif., Jan. 24-26, 1977, 12 p.  
 ABS: The design of a thermal protection system for a probe entry into the outer planets will require careful consideration since the heat shield weight will comprise a large percentage of the probe weight. The heat shield must be designed to withstand extremely high convective and radiative heating rates which result in significant mass loss and shape change, and which in turn has a major effect on both the trajectory, through a changing ballistic coefficient, and on the thermal environment. A steady-state shape change computer code has been developed for outer planet probe designs. A description of the code and typical results are presented in this paper.  
 MAJS: /•ABLATION/•ATMOSPHERIC ENTRY/•COMPUTERIZED SIMULATION /•HEAT SHIELDING/•PLANETARY ATMOSPHERES/•STEADY STATE

77A20516

UTTL: Simulation of the ablation process of meteorites under laboratory conditions, using supersonic plasma flows  
 AUTH: A/SULTANOV, M. A. Astronomicheskii Vestnik, vol. 10, Oct.-Dec. 1976, p. 220-240. In Russian.  
 ABS: Plasma flows at Mach numbers on the order of 4 were used to study the ablation mechanism of meteorites. The experimental data and photographs obtained for metals indicate that ablation and removal of the liquid mass is the principal mechanism of disintegration. In particular, for iron meteorites, the degree of disintegration is higher when a barrier boundary layer forms on the surface of the metal; the ablation process is much less intense in the absence of a barrier layer. However, the ablation process also depends on the physicochemical properties of the test materials.

MAJS: /•ABLATION/•ATMOSPHERIC ENTRY SIMULATION/•BOUNDARY LAYER PLASMAS/•MAGNETOHYDRODYNAMIC FLOW/•METEOR TRAILS /•SUPERSONIC FLOW

77A19516

UTTL: Ablation performance of tungsten, copper-infiltrated tungsten and other metal systems in arc heated jets  
 AUTH: A/AUERBACH, I. American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 15th, Los Angeles, Calif., Jan. 24-26, 1977, 8 p. ERDA-supported research.

ABS:

The ablation performance of solid, porous, and copper-infiltrated tungstens, tantalum, and tantalum-tantalum carbide eutectic and a niobium-niobium carbide eutectic were studied in arc-heated jets at stagnation pressures of 2.2 to 17.9 MPa and bulk gas enthalpies of 4630 to 5890 J/g. Ablation resistance was found to be inversely related to the melting point. The greatest ablation resistance was shown by the solid and copper-infiltrated tungstens, where flaring occurred (low pressures) and the model face assumed an elliptic shape, the recession rate could be related to the radius of the major axis. With solid and copper-infiltrated tungstens, a sequence of shape changes occurred in the pressure range of 10 to 18 MPa (hemispheric to conic, to preobscidian, to right cylindrical) indicating that the initial turbulent flow was reversed to laminar flow. This conclusion was supported by a comparison of the ratio of recession rates in laminar and turbulent flow for graphites and metals. Transition appears to be dependent on the parameter, stagnation pressure/bulk gas enthalpy. The value of this parameter is similar for graphite as well as solid and copper-infiltrated tungstens.  
 MAJS: /•ABLATIVE MATERIALS/•EUTECTIC ALLOYS/•JET FLOW/•NIOBIUM ALLOYS/•TANTALUM ALLOYS/•TUNGSTEN

77A19507

UTTL: A coupled 10 MW arc ablation-erosion test facility  
 AUTH: A/DICRISTINA, V.; B/HOERCHER, H.; C/SIEGELMAN, D. American Society of Mechanical Engineers, Intersociety Conference on Environmental Systems, San Diego, Calif., July 12-15, 1976, 6 p.  
 ABS: It is known that high-speed reentry vehicle performance is degraded when particle-laden cloud formations are traversed during reentry and that nosetip and heatshield materials experience increased surface recession as a result of combined ablation and particle erosion. The paper describes a coupled 10-MW arc ablation-erosion test facility which is a modified version of the Avco 10-MW arc system to enable discrete graphite particles of known size to be directly injected into the superheated test gas without altering the basic arc operating characteristics. Particle velocity is achieved by aerodynamic acceleration in a supersonic nozzle. Figures are presented showing the test comparisons of particle erosion and particle-free ablation for stainless steel, tungsten, and carbon-carbon materials. At present, the prime use of this test facility will be to evaluate nonreactive nosetip heat protection systems and to conduct coupled ablation-erosion phenomenology studies for analytical

# modeling and for passive material performance evaluation.

MAJS: /\*ABLATIVE MATERIALS/\*ATMOSPHERIC ENTRY SIMULATION/\* ENVIRONMENT SIMULATION/\*EROSION/\*REENTRY PHYSICS/\*TEST FACILITIES

77A18878

UTTL: Effects of porosity in graphite materials on ablation in arc-heated jets  
AUTH: A/AUC:GACH. I.: B/LIEDERMAN, M. L.: C/LAWSON, K. E.: D/FILSON, H. O.  
Journal of Spacecraft and Rockets, vol. 14, Jan. 1977, p. 19-24. EDA-supported research.

ABS: The ablation performance of chemically vapor-deposited carbon on a carbon felt made from polyacrylonitrile fiber, AFJ-S, and AFJ-S precursor graphites was studied in an arc jet at stagnation pressures and bulk gas enthalpies of 2.2 to 10.3 MPa and 4700 to 5800 J/g, respectively. The initial nonlinear ablation kinetics is associated with the attainment of thermal and chemical equilibrium. In the subsequent steady-state period, the ablation rate is constant. Ablation was modeled with an exponential rate relationship and the steady-state rate constants were shown to be related exponentially to porosity. A scanning electron microscope examination of ablated surfaces showed that nonuniform surface ablation can be correlated with porosity, fiber density, and the fiber matrix interfacial spacing.  
MAJS: /\*ABLATION/\*ARC HEATING/\*CARBON-CARBON COMPOSITES/\* GRAPHITE/\*POROSITY/\*VAPOR DEPOSITION

77A18G05

UTTL: Calculation of nonuniform plasma acceleration with allowance for dielectric ablation  
AUTH: A/GUSHCHIN, I. S.: B/POPOV, I. U. P.: C/SAVICHEV, V. V.  
Fizika Plazmy, vol. 2, Sept.-Oct. 1976, p. 742-749. In Russian.

ABS: Nonuniform plasma acceleration in a pulsed electromagnetic accelerator is analyzed in the framework of a one-dimensional MHD model, taking ablation of the plasma-forming dielectric during the discharge into account. The problem is solved numerically by the finite-difference method for a dielectric consisting of Teflon-4. The results give a detailed picture of the dynamics of current, magnetic field, and plasma-parameter redistribution during the discharge. It is noted that the calculated plasma and accelerator parameters are in good qualitative agreement with experimental results.

MAJS: /\*ABLATIVE MATERIALS/\*DIELECTRICS/\*NONUNIFORM PLASMAS

# /\*PLASMA ACCELERATION

77A17698

UTTL: The role of the boundary layer in the formation of shock waves when bodies are overtaken and swept by a supersonic plasma stream  
AUTH: A/SULTANOV, M. A.

ABS: Akademiia Nauk Tadzhikskoi SSR, Doklady, vol. 19, no. 7, 1976, p. 22-25. In Russian.  
The article draws attention to the role played by the boundary layer in variations of parameters of a discontinuity (shock wave) and of the ablative properties when bodies are impinged upon and swept by the shock. Cases where the bodies are incorporated in or joined to a metallic mass up to the 'earth' are considered. Results of investigations on reduction of ablation of bodies with the electron heat transfer mechanism operative in flow of a supersonic plasma over the body at Mach 4 (plasma formed in a high-power pulsed discharge) are reported. Differences in the behavior of different target materials are considered.  
MAJS: /\*ABLATION/\*AERODYNAMIC HEATING/\*BOUNDARY LAYER PLASMAS/\*SHOCK WAVES/\*SPACECRAFT REENTRY/\*SUPERSONIC FLOW

77A17604

UTTL: A study of transient thermal response of ablation materials  
AUTH: A/ARAI, N.  
Tokyo, University, Institute of Space and Aeronautical Science, Report no. 544, vol. 41, Sept. 1976, p. 259-260.

ABS: A thermal analysis for transient response of ablating materials made of high molecular compounds is developed on the basis of the two-layer thermal model by use of an appropriate numerical method, where the assumptions of quasi-steady boundary layer flow and the equilibrium vaporization at the ablating surface are employed. Numerical computation is carried for an ablating blunt body of revolution made of Teflon with an emphasis laid on the effect of the second-order transition - i.e., the gel layer. It is shown that the transient internal temperature near the ablating surface is diminished considerably by the existence of the gel layer. Comparison of the numerical results with the experimental data reveals a remarkable fact that the single-layer thermal model does not predict the real feature of the transient thermal field, while the two-layer thermal model agrees well with the experiment, thus confirming the validity of the present approach.

MAJS: /\*ABLATIVE MATERIALS/\*BLUNT BODIES/\*BOUNDARY LAYER

FLOW/REENTRY SHIELDING/\*TRANSIENT RESPONSE/\*  
TRANSITION TEMPERATURE

77A16056

UTTL: Temperature dependence of the absorption edge of vitreous silica  
AUTH: A/BATES, C. W., JR. CORP: Stanford Univ., Calif.  
Applied Optics, vol. 15, Dec. 1976, p. 2976-2978.  
ABS: During an investigation of the optical properties of high-purity vitreous silica (fused quartz), which is being developed by NASA as a reflective and ablative heat shield, some interesting properties of theoretical and experimental nature have become apparent which otherwise may have remained unnoticed. Of particular interest for the NASA application is the shift of the absorption edge toward longer wavelengths with increasing temperature. The results of studies of this shift and of the spectral dependence of the absorption edge are summarized in the present paper. Plots of the absorption edge and the absorption spectrum of fused quartz vs temperature are given and discussed.

MAJS: /\*ABLATIVE MATERIALS/\*ABSORPTION SPECTRA/\*REENTRY SHIELDING/\*SILICON DIOXIDE/\*TEMPERATURE EFFECTS/\*VITREOUS MATERIALS

77A15359

UTTL: Equation of meteor disintegration with allowance for heating

AUTH: A/KRUCHINENKO, V. G.  
Problemy Kosmicheskoi Fiziki, no. 11, 1976, p. 56-62.  
In Russian

ABS: It is noted that the classical equation of meteor vaporization does not allow for the fact that some of the thermal energy produced is expended in heating the inner parts of the object. The present paper determines this expenditure more precisely. Some approximations are used to solve the equation of heat conduction with a boundary condition that takes into account the decrease in meteor size during ablation. Analytical solutions to the problem are obtained for large and small meteors. The results obtained by the classical approach and the present technique are compared with each other as well as with observational data.

MAJS: /\*ABLATION/\*ATMOSPHERIC ENTRY/\*DISINTEGRATION/\*METEOROIDS

77A15089

UTTL: Theoretical and experimental evaluation of pulsed plasma thrusters

AUTH: A/ANDRENUCCI, M.; B/LAZZARETTI, R.  
American Institute of Aeronautics and Astronautics, International Electric Propulsion Conference, Key Biscayne, Fla., Nov. 14-17, 1976, 11 p.

ABS: Theoretical aspects of pulsed-plasma-thruster design and operation are reviewed together with some results of a continuing experimental program. The use of theoretical models for obtaining performance predictions is discussed, and the application of theoretical results to designing a thruster with specific characteristics is described. Thrusters of the ablative type are then considered in particular. A general discussion is given of theoretical problems involved in improving their performance. Current design criteria are analyzed, especially the assumption of a linear dependence of the mass ablated per shot on energy. Preliminary results obtained with an experimental model of a coaxial ablative thruster are presented and analyzed.

MAJS: /\*ABLATION/\*ENGINE DESIGN/\*PERFORMANCE PREDICTION/\*PLASMA ENGINES/\*PROPULSION SYSTEM PERFORMANCE/\*PULSED JET ENGINES/\*SOLID PROPELLANT ROCKET ENGINES

77A14318

UTTL: Experimental determination of plasma jet parameters  
AUTH: A/SAKHIEV, A. S.; B/STELMAKH, G. P.; C/RIABTSEV, E. I.; D/KOSARENKOV, V. A.; E/SHIMCHUK, V. P.; F/CHEENOKOV, N. A.  
Inzhenerno-Fizicheskii Zhurnal, vol. 31, Sept. 1976, p. 431-436. In Russian.

ABS: A gaseodynamic facility was used to generate high-enthalpy argon flows ( $M = 3.5$ ) suitable for investigating the ablation characteristics of materials. The experiments described were aimed at determining the uniformity of the pressure and temperature (enthalpy) distributions across the jet and at determining the optimum location of the sample. Data obtained from thermal and gaseodynamic diagnostics of the argon jets are diagrammed and discussed.

MAJS: /\*ABLATIVE MATERIALS/\*ARGON PLASMA/\*PLASMA JETS/\*SUPERSONIC JET FLOW

77A13723

UTTL: Effects of atomic oxygen on graphite ablation

AUTH: A/PARK, C. CORP: National Aeronautics and Space Administration, Ames Research Center, Moffett Field, Calif.

ABS: AIAA Journal, vol. 14, Nov. 1976, p. 1640-1642.  
It is shown that a previously derived semilempirical

equation for describing observed ablation rates of isotropic graphites cannot be applied to low-density flows containing dissociated oxygen. Experimentally determined reaction probabilities of isotropic graphites to molecular and atomic oxygen are used to calculate heat-transfer rates and stagnation-point ablation rates for typical conditions. Integrated mass losses are computed for a group of flight trajectories which start from geosynchronous orbit and enter earth's atmosphere in a skipping motion following near-elliptic decaying orbits. A comparison of the results with those obtained by the equation under question shows excellent agreement for steep trajectories, but large discrepancies for shallow trajectories. The differences are attributed to surface oxidation by atomic oxygen.

MAJS: /•ABLATIVE MATERIALS/•GRAPHITE/•OXYGEN ATOMS/•REENTRY PHYSICS

77A13069

UTTL: Calculation of the disintegration of the Lost City, Grant, and Pribram meteorites during entry into the earth's atmosphere

AUTH: A/OVSIAHNIKOV, V. M.  
Astronomicheskii Vestnik, vol. 10, July-Sept. 1976, p. 151-157. In Russian.

ABS: A method is proposed for calculating the heat-induced disintegration of meteorites entering the atmosphere at speeds below 21 km/s. The heat component of mass removal calculated for three representative meteorites is found to correlate well with the results obtained by other methods.

MAJS: /•ABLATION/•AEROTHERMODYNAMICS/•ATMOSPHERIC ENTRY/•BLUNT BODIES/•METEORITES/•PRIBRAM METEORITE

77A11540

UTTL: Thermal tile production ready to roll

AUTH: A/OLONE, R. G.  
Aviation Week and Space Technology, vol. 105, Nov. 8, 1976, p. 51, 53, 54.

ABS: Manufacturing and production of the tiles forming the ablative heat shield of Shuttle Orbiter are outlined. Problems in the production, shaping, and dimensioning of the 34,000 unique tiles in the thermal protection system of each Orbiter are discussed. Development of the reaction-cured glass (RCG) tile coating, measures to ensure provisioning of high-purity silica, and materials requirements for the lower-temperature and elevated-temperature tiles are covered. Technological complexities in numerically controlled (NC) milling of thousands of unique tiles, and costs associated with NC tape quantity zero-defect custom production runs,

are sketched.

MAJS: /•ABLATIVE MATERIALS/•BOROSILICATE GLASS/•HEAT SHIELDING/•PRODUCTION ENGINEERING/•SPACE SHUTTLE ORBITERS/•THERMAL CONTROL COATINGS

77A10939

UTTL: Strength of glass-fibre-reinforced plastics at one-sided heating

AUTH: A/PISARENKO, G. S.; B/TRETIACHENKO, G. N.  
International Astronautical Federation, International Astronautical Congress, 27th, Anaheim, Calif., Oct. 10-16, 1976, 8 p.

ABS: The surfaces of modern high-speed aircraft are protected from aerodynamic heating by coatings prepared of ablating materials, such as fiberglass laminates, asbestos textolites, carbon-base materials, and composites, each of whose elements serves a specific (load-carrying, insulating, etc.) purpose. The facilities described in the present paper are designed for testing such protective coatings in bending, tension, or compression under unilateral heating. Some techniques used to simulate the actual heating conditions are discussed.

MAJS: /•ABLATIVE MATERIALS/•AERODYNAMIC HEATING/•AIRCRAFT STRUCTURES/•GLASS FIBER REINFORCED PLASTICS/•MECHANICAL PROPERTIES/•THERMAL CONTROL COATINGS

77A10219

UTTL: Radiative ablation of melting solids

AUTH: A/PRASAD, A.; B/SINHA, S. N.  
AIAA Journal, vol. 14, Oct. 1976, p. 1494-1497.

ABS: Radiative ablation occurring in melting solids when a large temperature difference exists between the solid and the environment from which the solid receives heat is regarded as a phase change problem. Biot's variational method is used to obtain closed-form solutions for melting distance and surface temperature when ablation occurs in the melting solid as a result of radiative heating. A numerical solution is also obtained using Simpson's rule. It is found that for any value of the dimensionless temperature (beta) of the surroundings, both the surface temperature and the melting distance increase with an increase in time and that they decrease at any time with an increase in beta.

MAJS: /•ABLATION/•BIOT METHOD/•MELTING/•RADIATIVE HEAT TRANSFER

76A46732

UTTL: The chemical reduction of meteoric metal oxides as a source of meteor train emission  
AUTH: A/BAGCALEY, W. J.  
Astronomical Institutes of Czechoslovakia, Bulletin, vol. 27, no. 4, 1976, p. 244-246.  
MAJS: /\*ABLATIVE MATERIALS/\*METAL OXIDES/\*METEOR TRAILS/\*REDUCTION (CHEMISTRY)

76A44507

UTTL: Exploratory studies in polymer ablation. Ignition and extinction by the moving wire technique  
AUTH: A/FRISTROM, R. M.; B/GRUNFELDER, C.; C/HUNTER, L. W. Combustion and Flame, vol. 27, Aug. 1976, p. 33-49.  
ABS: National Fire Prevention and Control Administration  
A new technique consisting of moving a wire at a controlled speed through a stationary ignition source has been developed for measuring polymer ablation, ignition and extinction. Temperature and oxygen profiles of the ignition source are taken to define the elements of the system. The characteristic residence times at ignition and extinction of Teflon, PVC and rubber were measured as a function of the concentration of the available oxygen.  
MAJS: /\*ABLATION/\*COMBUSTION PHYSICS/\*IGNITION/\*POLYMER PHYSICS

76A39507

UTTL: Entry into outer planet environments. I - The radiating shock layer with coupled ablation for carbon and silica  
AUTH: A/LIU, C.-H.; B/HOWE, J. T. CORP: National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.  
American Institute of Aeronautics and Astronautics, Thermophysics Conference, 11th, San Diego, Calif., July 14-16, 8 p.  
ABS: Fully coupled solutions of shock layer equations for the stagnation region are obtained, comprising a set of converged benchmark flowfield solutions for silica and carbon heat shields entering modeled atmospheres of Saturn and Uranus. Model atmospheres and entry trajectories providing significant radiative heating to the entry probes so that the heating environment and effects of mass addition on the heating environment are clearly defined are emphasized. Results referable to the carbon heat shield are questioned because of the high (sublimation) wall temperature assumed and the relatively low shock layer temperature.  
MAJS: /\*ABLATION/\*ATMOSPHERIC ENTRY/\*CARBON/\*PLANETARY ENVIRONMENTS/\*SHOCK LAYERS/\*SILICON DIOXIDE

76A38213

UTTL: Nozzle designs with pitch precursor ablatives  
AUTH: A/BLEVINS, H. R.; B/BEDARD, R. J. CORP: Acurex Corp., Mountain View, Calif.; National Aeronautics and Space Administration, Marshall Space Flight Center, Huntsville, Ala.  
American Institute of Aeronautics and Astronautics and Society of Automotive Engineers, Propulsion Conference, 12th, Palo Alto, Calif., July 26-29, 1976, AIAA 9 p.

ABS:

Recent developments in carbon phenolic ablatives for solid rocket motor nozzles have yielded a pitch precursor carbon fiber offering significant raw material availability and cost saving advantages as compared to conventional rayon precursor material. This paper discusses the results of an experimental program conducted to assess the thermal performance and characterize the thermal properties of pitch precursor carbon phenolic ablatives. The end result of this program is the complete thermal characterization of pitch fabric, pitch mat, hybrid pitch/rayon fabric and pitch mat molding compound. With these properties determined an analytic capability now exists for predicting the thermal performance of these materials in rocket nozzle liner applications. Further planned efforts to verify material performance and analytical prediction procedures through actual rocket motor firings are also discussed.

MAJS: /\*ABLATIVE MATERIALS/\*NOZZLE DESIGN/\*PHENOLIC RESINS/\*SOLID PROPELLANT ROCKET ENGINES/\*THERMODYNAMIC PROPERTIES

76A38162

UTTL: Carbon-carbon materials for nozzles of solid propellant rocket motors  
AUTH: A/CHOURY, J. J.

American Institute of Aeronautics and Astronautics and Society of Automotive Engineers, Propulsion Conference, 12th, Palo Alto, Calif., July 26-29, 1976, AIAA 7 p.

ABS:

The ablation resistance of several types of carbon-carbon materials when tested in conditions representative of a full scale firing test is presented. It is shown that the ablation resistance of a carbon-carbon material vary almost linearly with its density. This characteristic is very important because it permits use in place of classical materials for nozzle components (phenolic composition, graphites, pyrolytic graphite) carbon-carbon materials with the same ablation resistance but with improved thermal stability and physicochemical and thermomechanical properties making the design of these nozzles easier and more reliable. The advantages of these different

types of carbon-carbon materials when compared with the phenolic composites, graphites and pyrolytic graphite are presented. Future trends to advance the state of the art in manufacturing of this carbon-carbon material are discussed.

MAJS: /\*ABLATIVE MATERIALS/\*CARBON-CARBON COMPOSITES/\*FULL SCALE TESTS/\*MATERIALS TESTS/\*ROCKET NOZZLES/\*SOLID PROPELLANT ROCKET ENGINES

76A27008

UTTL: Boundary-layer transition experiments on pre-ablated graphite nosetips in a hypersonic range

AUTH: A/NEIDA, D. C.; B/LEVERANCE, R. A.  
American Institute of Aeronautics and Astronautics, Fluid and Plasma Dynamics Conference, 9th, San Diego, Calif., July 14-16, 1976. 20 p.

ABS: An experimental program was conducted to test the validity of extrapolating the PANT (Passive Nosetip Technology) boundary-layer transition correlation, based on wind-tunnel/calorimeter-model results, to actual nosetip materials exposed to actual reentry environments. Pre-ablated AFU-S graphite nosetips were flown on specific ballistic range trajectories through both air and nitrogen (with and without ablation). Surface temperature contours were measured via electro-optical pyrometry, from which transition zone presence and location were inferred. Significant discrepancies were noted between predicted and experimentally observed transition zone behavior, as influenced by Reynolds number and wall-temperature effects. A question was raised concerning characterization of a surface microroughness distribution, for transition purposes, by its mean value. In addition, significant surface roughness effects on laminar-flow heat-transfer rates were noted

MAJS: /\*ABLATION/\*BOUNDARY LAYER TRANSITION/\*GRAPHITE/\*HEAT TRANSFER COEFFICIENTS/\*HYPERVELOCITY FLOW/\*NOSES (FOREBODIES)

76A36018

UTTL: An investigation of ablation-induced roll torques on reentry vehicles

AUTH: A/KRYVORUKA, J. K.; B/BRAMLETTE, T. T.  
In: Atmospheric Flight Mechanics Conference, 3rd, Arlington, Tex., June 7-9, 1976. Proceedings. (A76-36901 17-08) New York, American Institute of Aeronautics and Astronautics, Inc., 1976. p. 160-168. ERDA-supported research.

ABS: The results of a reentry vehicle flight test program to evaluate the roll-producing effect of an ablating tape-wrapped carbon phenolic (TNCP) heat shield are presented. Included is a description of the thermal

shield construction, which reveals the presence of small aerodynamic surfaces. Exposed by the ablation process during severe reentry environment, these surfaces are capable of producing significant rolling moments. Instrumentation on board the flight vehicle, designed to evaluate the aerodynamic and thermal response, indicated that the desired flight environment was achieved and that there was sufficient ablation to generate roll torque. A discussion of theoretical methods to predict the rolling moment coefficients is presented, as well as a comparison of the predicted coefficients with flight data. The vehicle was recovered intact, and the postflight inspection is described.

MAJS: /\*ABLATION/\*HEAT SHIELDING/\*PERFORMANCE PREDICTION/\*REENTRY VEHICLES/\*ROLLING MOMENTS

76A36817

UTTL: Heat and mass transfer within Teflon layers in ablation cooling

AUTH: A/HOLZKNECHT, B.; B/STEPHAN, K.  
(Deutsche Gesellschaft fuer Luft- und Raumfahrt, Fachausschussitzung ueber Waermeuebergang und Ablation, Cologne, West Germany, May 15, 1975.)  
Waerme- und Stoffuebertragung, vol. 9, no. 2, 1976. p. 73-77. In German.

ABS: For the transient, one-dimensional ablation of a Teflon ablation layer an analytical model has been developed. It takes into account the crystalline-amorphous phase transition, the thermal expansion, the depolymerization and the formation of higher-molecular products at the surface. The results of the numerical computation are compared with ablation measurements in arc jet facilities for transient ablation and the limiting case of quasi-steady ablation. The course of the ablation process in principle is illustrated, and different influences and limiting cases are investigated.

MAJS: /\*ABLATIVE MATERIALS/\*HEAT TRANSFER/\*MASS TRANSFER/\*SURFACE LAYERS/\*TEFLON (TRADEMARK)

76A35414

UTTL: Finite difference solution of the inverse heat conduction problem and ablation

AUTH: A/RAINDALL, J. D.  
In: Heat Transfer and Fluid Mechanics Institute, Meeting, 25th, Davis, Calif., June 21-23, 1976. Proceedings. (A76-35401 17-34) Stanford, Calif., Stanford University Press, 1976. p. 257-269. ERDA-sponsored research.

ABS: An unconditionally stable algorithm is proposed for numerical finite-difference solution of linear and



nonlinear inverse heat conduction problems. The finite-difference analysis of ablation problems, including multidimensional problems with liquid melt layers, is facilitated by embedding them in inverse heat conduction problems. The accuracy of the finite-difference solution is assessed by comparing it with a solution using a more conventional finite-difference method and an alternative more accurate solution of the ablation problem. The possibility of extending the inverse conduction finite-difference method to more complex ablation problems is discussed.

MAJS: /\*ABLATION/\*CONDUCTIVE HEAT TRANSFER/\*FINITE DIFFERENCE THEORY

76A33701

UTTL: Reinforced plastics applied in aviation, projectiles, rockets, and space vehicles

AUTH: A/SALVADOR LOPEZ, J. M.

IAA/Ingeniería Aeronáutica y Astronáutica, vol. 28, Apr. 1976, p. 23-29. In Spanish.

MAJS: /\*ABLATION/\*AEROSPACE ENGINEERING/\*REINFORCED PLASTICS /\*SPACECRAFT STRUCTURES/\*TECHNOLOGY UTILIZATION/\*THERMOPLASTIC RESINS

76A27020

UTTL: Motion of large bodies in the atmospheres of planets

AUTH: A/PEIKOV, G. I.; B/STULOV, V. P.

(Kosmicheskie Issledovaniia, vol. 13, July-Aug. 1975, p. 597-594.) Cosmic Research, vol. 13, no. 4, Jan. 1976, p. 525-531. Translation.

ABS: (For abstract see issue 23, p. 3472. Accession no. A75-45295)

MAJS: /\*ABLATION/\*ATMOSPHERIC ENTRY/\*METEORIDS/\*PLANETARY ATMOSPHERES/\*RADIATIVE HEAT TRANSFER

76A26033

UTTL: Is fragmentation the answer to the difference in the dynamic and photometric masses of fireballs

AUTH: A/PADEVET, V.

Astronomical Institutes of Czechoslovakia. Bulletin, vol. 27, no. 1, 1976, p. 11-18.

ABS: An attempt is made to find an ablation mechanism for large meteoroids in supersonic flow which would be independent of differences in the densities and mechanical strengths of the meteoroids. The mechanism would explain the order-of-magnitude difference in the masses of fireballs determined by photometric and dynamic methods. The fragmentation of the meteoroid and the motion of the fragments in the perturbed wake of the meteoroid would be able to explain the

experimentally determined difference in masses only at high altitudes. It is shown that not even the presence of a shock wave in front of the meteoroid can explain the mass difference at lower altitudes.

MAJS: /\*ABLATION/\*BOLIDES/\*FRAGMENTATION/\*SHOCK WAVES/\*SUPERSONIC FLOW

76A23655

UTTL: Correlation of theoretical analysis with experimental data on the performance of charring ablators

AUTH: A/MASTANAIKH, K.

(American Society of Mechanical Engineers, 1976.) ASME Transactions, Series C - Journal of Heat Transfer, vol. 98, Feb. 1976, p. 139-143.

ABS: Experimental data are obtained for surface recession, char depth, and temperatures in silica phenolic and carbon phenolic ablators from static test conducted on rocket nozzles. In order to correlate the theoretical analysis with the experimental observations, it is found that the effective thermal conductivity of char is strongly dependent on the wall heat flux. A hypothesis is postulated that the char conductivity can best be correlated by cold wall heat flux treated as a generalized variable that includes the effects of other factors like temperature and chemical composition of the char. Exponential dependence of char conductivity on the cold wall heat flux is observed for both the ablators, and has offered excellent comparison between the theoretical and the experimental system response.

MAJS: /\*ABLATIVE MATERIALS/\*CHARRING/\*ROCKET NOZZLES/\*THERMAL CONDUCTIVITY

76A23424

UTTL: Heat transfer with thermal control applications

AUTH: A/YOVANOVICH, M. M.

New York, American Institute of Aeronautics and Astronautics, Inc. (Progress in Aeronautics and Astronautics, Volume 39), 1975, 504 p

ABS: Thermal and experimental aspects of thermal contact resistance are considered, taking into account a random-process analysis of the effect of waviness on thermal contact resistance, the effect of interfacial distortions on the thermal contact resistance of coaxial cylinders, and the thermal constriction resistance of a disk with arbitrary heat flux. Aspects of heat pipe analysis and performance are discussed, giving attention to the theoretical and experimental investigation of two-component heat pipes, the laminar flow in annuli and flat-plate channels, and the development of a blocking orifice thermal diode heat pipe. Surface radiation properties

and gaseous radiative interactions are examined in a description of radiative transfer. Ablation-related subjects are also investigated.

MAJS: /\*ABLATIVE MATERIALS/\*CONTACT RESISTANCE/\*HEAT PIPES/\*RADIATIVE HEAT TRANSFER/\*TEMPERATURE CONTROL/\*THERMAL RESISTANCE

76A22744

UTTL: Two-component force balance for measuring skin friction and side force

AUTH: A/HOFANOFF, E. V.; E/DRIFTMYER, R. T.  
In: ICIAF '75; International Congress on Instrumentation in Aerospace Simulation Facilities, 6th, Ottawa, Canada, September 22-24, 1975. Record. (A76-22728 09-09) New York, Institute of Electrical and Electronics Engineers, Inc., 1975. p. 161-169.

ABS: A two-component force balance was constructed which measured simultaneously the skin-friction force (drag force on a missile) and the orthogonal side force (roll-torque producing force). The test samples reported herein were designed to demonstrate the measurement technique. They were fabricated from aluminum. A successful test was performed in the NAVSURFWPNCEN Boundary Layer Channel using these aluminum test samples.

MAJS: /\*ABLATIVE MATERIALS/\*ACRODYNAMIC FORCES/\*FRICTION MEASUREMENT/\*LATERAL STABILITY/\*SKIN FRICTION/\*WEIGHT INDICATORS

76A18247

UTTL: Analytical study of heat conduction with phase transition

AUTH: A/ZIEN, T.-F.  
American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 14th, Washington, D.C., Jan. 26-28, 1976. 14 p. Navy-supported research.

ABS: An integral approach is proposed for the approximate solution of transient heat conduction problems involving moving boundary and phase changes such as heat conduction in a melting solid. In the application to heat conduction calculations, the method can be viewed as a refinement of Goodman's (1964) heat-balance integral method which is based on the classical Karman-Pohlhausen momentum integral technique in the boundary layer theory. The basic idea of the proposed method lies in the use of the first integration of the heat equation as the expression for the boundary heat flux. A variant of the calculation scheme is presented in which use is made of the first integration equation and a theta-moment equation generated by first multiplying the original heat equation by the temperature and then integrating in

the direction of heat diffusion. Idealized yet representative models of melting and ablation are treated.

MAJS: /\*ABLATION/\*ACRODYNAMIC HEATING/\*CONDUCTIVE HEAT TRANSFER/\*DIFFERENTIAL THERMAL ANALYSIS/\*PHASE TRANSFORMATIONS/\*REENTRY EFFECTS

76A16101

UTTL: Criteria for identification of ablation debris from primitive meteoric bodies

AUTH: A/BROWNLEE, D. E.; B/BLANCHARD, M. B.; C/CUNNINGHAM, G. C.; D/BEAUCHAMP, R. H.; E/FRULAND, R. CORP.; Battelle Pacific Northwest Labs., Richland, Wash.; National Aeronautics and Space Administration, Ames Research Center, Moffett Field, Calif.; National Aeronautics and Space Administration, Lyndon B. Johnson Space Center, Houston, Tex.; Oregon Univ., Eugene.; Washington Univ., Seattle.  
Journal of Geophysical Research, vol. 80, Dec. 10, 1975. p. 4917-4924.

ABS: Samples of ablated materials are analyzed to determine properties expected to be characteristic of particulates generated by the ablation of primitive meteoric bodies. Analyses of carbonaceous-chondrite fusion crusts and samples artificially ablated in the laboratory indicate that most meteor-ablation debris should consist of assemblages of silicate minerals, principally olivine, and micron-sized magnetic grains. It is expected that ablation debris of at least 10 microns should have abundances of Fe, Mg, Si, Ca, and Ni similar to those found in chondritic meteorites. Volatile species such as S, H<sub>2</sub>O, and Cl are lost during ablation and normally should not be found in ablated material. The major findings of this study are supported by analysis of spherules collected in the atmosphere which are thought, on separate grounds, to be genuine meteor-ablation products. The majority of meteoric bodies probably have cometary origins, and it is hoped that the ability to collect and identify meteor-ablation debris reliably will provide an opportunity to do laboratory analysis of cometary matter.

MAJS: /\*ABLATION/\*ABUNDANCE/\*CARBONACEOUS CHONDRITES/\*METEORITIC COMPOSITION/\*PARTICULATE SAMPLING/\*SPACE DEBRIS

76A15322

UTTL: On the estimation of aerodynamic blocking in heat-transfer studies of char-forming ablators

AUTH: A/STOLARIK, E.  
Aeronautical Journal, vol. 79, Nov. 1975. p. 499-505.  
Research sponsored by the Northrop Corp.

**ABS:** Simpler relationships for predicting aerodynamic blocking effects on heat transfer by char-forming ablators are sought, in order to reduce computing time. Results of the Norair heat-transfer program can be simulated for re-entry from circular orbits by relying on linear ablation theory with a constant transpiration factor. A simple method of estimating the amount of heat conducted into the material, useful in some engineering applications, is devised on the basis of an experimental correlation of vapor injection rates.

**MAJS:** /ABLATIVES MATERIALS/-AERODYNAMIC HEATING/-HEAT TRANSFER

**UTTL:** 76A15246  
 Response of charring ablators to severe aerodynamic and erosion environments

**AUTH:** A/CLEVER, R. M.; B/DENNY, V. E.  
 Journal of Spacecraft and Rockets, vol. 12, Sept. 1975, p. 558-564.

**ABS:** Results of an analytical study for the transient and quasi-steady response of a typical charring ablator to severe aerodynamic and erosion environments are reported for heating loads and particle-surface interactions which are representative of wind tunnel tests as well as re-entry conditions. The coupled erosion-char formation process is shown to be self-limiting, and both discrete and continuous models for erosion of partially charred material, based on experimental data for virgin and fully charred material, are found to give similar results. The numerical solution procedure is illustrated for typical re-entry conditions with cloud and/or dust layers located at altitudes of 50, 35, and 10 kft. Application of simple quasi-steady theory is shown to under-predict total recession.

**MAJS:** /ABLATIVES MATERIALS/-AERODYNAMIC HEATING/-EROSION/-REENTRY SHIELDING/-TRANSIENT RESPONSE

**UTTL:** 76A15085  
 Cometary debris

**AUTH:** A/MCCROSKY, R. E.  
 In: The dusty universe. (A76-15076 04-90) New York, Neale Watson Academic Publications, Inc., 1975, p. 169-184.

**ABS:** Problems of ablation mechanisms of cometary nuclei are discussed in the light of some specific observations of comets and meteors. Estimates of the mass in the Geminid meteor stream are given. The outbursts of Comet P/Tuttle-Giacobini-Kresak are compared with those of the more distant comet P/Schwassman-Wachmann 1. A formal solution of heat shock effects in comets

near perihelion is given as an upper limit of the efficacy of this process for cometary disruption.

**MAJS:** /ABLATIVES MATERIALS/-ASTRONOMICAL MODELS/-COMET NUCLEI/-GEMINID METEORIDS/-SPACE DEBRIS

**UTTL:** 76A14808  
 Surface patterns on subliming and liquefying ablation materials

**AUTH:** A/STOCK, H. W.  
 AIAA Journal, vol. 13, Sept. 1975, p. 1217-1223.

**ABS:** The cross-hatching phenomenon has been studied experimentally at a freestream Mach number of 5.3, using two different low temperature ablation materials, camphor and wax, which sublime and liquefy, respectively, under the test conditions. The surface pattern parameters (i.e., the exit angle and the streamwise spacing) have been compared for both ablation modes and correlated with flowfield properties. The effect of exposure time under ablation conditions has been studied. It has been qualitatively shown that the viscosity of the solid ablation material influences the streamwise spacing. Streamwise vortices which occasionally develop in the boundary layer have no influence on the pattern formation.

**MAJS:** /ABLATIVES MATERIALS/-LIQUEFACTION/-SUBLIMATION/-SURFACE PROPERTIES

**UTTL:** 76A13432  
 A quantitative model for the ablation of dustball meteors

**AUTH:** A/HAWKES, R. L.; B/JONES, J.  
 Royal Astronomical Society, Monthly Notices, vol. 173, Nov. 1975, p. 339-356. Research supported by the National Research Council of Canada.

**ABS:** A quantitative model for the ablation of dustball meteors is presented. The model assumes meteoric bodies are composed of grains held together by a lower boiling point 'glue'. Once the boiling point of the 'glue' is reached grains are detached. Light is assumed to be produced only by detached grains. For meteors fainter than about +5 magnitude, the grains are detached above the radiation ceiling, and the heights of such meteors are mass independent. For brighter meteors, grain detachment and ablation occur simultaneously and the model predicts approximately classical light curves.

**MAJS:** /ABLATIVES MATERIALS/-ASTRONOMICAL MODELS/-INTERPLANETARY DUST/-METEOROID DUST CLOUDS

75A45295

UTTL: Motion of large bodies in planetary atmospheres

AUTH: A/PETROV, G. I.; B/STULOV, V. P.

MAJS: Kosmicheskie Issledovaniia, vol. 13, July-Aug. 1975, p. 587-594. In Russian.

ABS: The motion of large bodies in planetary atmospheres is considered in the case of a high entry velocity. Data are presented concerning radiative heat exchange of such bodies, and it is shown that during intense radiative heating, ablation occurs by means of mixing with an external flow in a free boundary layer. An ablation equation is proposed, and its exact solution is obtained. Total atmospheric dispersion of a body's high initial kinetic energy is found to be possible only for a low-density body. The possibility of cratering on Venus is analyzed. It is shown that the basic features of the Tunguska event can be duplicated by the entry of a low-density (less than 0.01 g/cm<sup>3</sup>) body with the subsequent evaporation and disintegration of its gas cloud. It is concluded that the forest was knocked down in this event as a result of a shock wave released from the incoming body as a consequence of its very rapid deceleration.

MAJS: /•ABLATION/•ATMOSPHERIC ENTRY/•METEOROID/•PLANETARY ATMOSPHERES/•RADIATIVE HEAT TRANSFER

75A44080

UTTL: Problems associated with unsteady heating of heat-shield materials

AUTH: A/POLEZHAEV, I. V.; B/KILLIKH, V. E.; C/NAROZHNYI, I. G.

ABS: Inzhenerno-Fizicheskii Zhurnal, vol. 29, July 1975, p. 39-44. In Russian.

Some aspects of the unsteady heating and decomposition (ablation) of heat-shield materials are examined, with particular reference to asbestos textile and reinforced plastic heat shields. The critical heating rates are established and the influence of the heating rate on the temperature dependence of the thermophysical properties of materials is demonstrated.

MAJS: /•ABLATIVE MATERIALS/•HEAT SHIELDING/•REINFORCED PLASTICS/•THERMAL CYCLING TESTS

75A42747

UTTL: Ablation and shape-density coefficients in meteors

AUTH: A/CEPLECHA, Z.

Astronomical Institutes of Czechoslovakia, Bulletin, vol. 26, no. 4, 1975, p. 242-248.

ABS: Six methods of computing the ablation coefficient and the shape-density coefficient for photographic meteors are given. They are suitable in cases when a big

change of meteor velocity is observed. The methods were applied to PN-fireballs, one of them being used as a numerical example in this paper.

MAJS: /•ABLATION/•DENSITY (MASS/VOLUME)/•FIREBALLS/•METEOR TRAILS/•PHOTOGRAPHIC MEASUREMENT

75A42467

UTTL: Fragmentation of the surfaces of heat shield materials during ablation

AUTH: A/BULANOV, V. N.; B/VASILEV, A. V.; C/FRANTSEVICH, I. N.; D/SHEVCHENKO, V. IA.

MAJS: Akademiia Nauk SSSR, Doklady, vol. 220, Jan. 21, 1975, p. 571-574. Soviet Physics - Doklady, vol. 20, July 1975, p. 67-69. Translation.

ABS: (Previously cited in issue 10, p. 1439. Accession no. A75-25585)

MAJS: /•ABLATIVE MATERIALS/•CARBON FIBER REINFORCED PLASTICS /•FRAGMENTATION/•HEAT SHIELDING/•SURFACE TEMPERATURE/•THERMAL PROTECTION

75A41967

UTTL: Thermal protection systems for aerodynamically controlled reentry bodies - Summary of developments in the ART program

AUTH: A/GRALLERT, H.

MAJS: Raumfahrtforschung, vol. 19, July-Aug. 1975, p. 188-209. In German.

ABS: General questions regarding the protection of reentry vehicles against aerodynamic-heating effects are considered along with the specific aspects investigated in the ART program. System studies are discussed and work related to the development of metallic radiation-insulation systems is reported. A description of theoretical investigations of ablative heat shields is presented. Attention is also given to experimental development work concerning ablative insulation systems.

MAJS: /•ABLATIVE MATERIALS/•AERODYNAMIC HEATING/•REENTRY VEHICLES/•SPACECRAFT SHIELDING/•THERMAL PROTECTION

75A38074

UTTL: Heat and mass transfer during high-enthalpy gas flow in aircraft and rocket engine flow passages

AUTH: A/FAURIN, A. V.; B/KRECHETNIKOV, I. U. D.; C/SEKICHEV, A. IA.; D/NADYROV, N. A.

MAJS: Aviatsionnaya Tekhnika, vol. 18, no. 1, 1975, p. 54-60. Soviet Aeronautics, vol. 18, no. 1, 1975, p. 43-48. Translation.

ABS: (For abstract see issue 13, p. 1881. Accession no. A75-25811)

MAJS: /•ABLATION/•AIRCRAFT ENGINES/•COMBUSTION CHAMBERS/•

# HIGH TEMPERATURE GASES/\*ROCKET LININGS/\*THERMAL CONTROL COATINGS

75A36562

UTTL: Investigation on a high current pulsed ablation plasma thruster

AUTH: A/LIEBIG, L.

In: European Electric Propulsion Conference, 3rd, Wintergarten, West Germany, October 14-18, 1974. Proceedings (A75-36537 17-20) Cologne, Deutsche Gesellschaft fuer Luft- und Raumfahrt, 1974, p. 167-170.

ABS: The present work describes efforts to improve the standard self-magnetic field ablative field accelerator by achieving more distinct ablation and acceleration phases with the aid of a permanent magnet. This permanent field was applied perpendicular to the anode wire so that its direction is opposite that of the self magnetic field. Thus a  $J \times B$  force is oriented toward the propellant surface at the beginning of the discharge when ablation has to take place and inverts its direction when the acceleration phase begins. This causes the ablation to take place within a well-defined region. Probe measurements have shown an excellent reproducibility of the ablation plasma. A spot-to-spot signal difference of more than 100% was revealed in comparison with measurements without permanent magnetic field. The amount of ablated propellant and the local distribution of ablation plasma before acceleration can be varied without changing the acceleration process.

MAJS: /\*ABLATION/\*HIGH CURRENT/\*PLASMA ACCELERATORS/\*PLASMA ENGINES/\*SPACECRAFT PROPULSION

75A36592

UTTL: Experimental characterization of ablative materials by plasma jet

AUTH: A/LABROT, M.

Association Aeronautique et Astronautique de France, Coll'que d'Aerodynamique Appliquee, 11th, Universite de Bordeaux I, Talence, Gironde, France, Nov. 6-8, 1974. Paper 26 D. In French.

ABS: After a brief recall of the principal physical and chemical phenomena put into play during the process of ablation and a succinct description of synthetic plasma generators presently in use, the current work discusses the performance of these generators in different material test configurations. It is concluded that plasma generators are a means of testing that is very well-adapted to the study of thermal protection materials for a vehicle reentering the atmosphere.

MAJS: /\*ABLATIVE MATERIALS/\*MATERIALS TESTS/\*PLASMA JETS/\*REENTRY VEHICLES/\*ROCKET NOSE CONES/\*THERMAL PROTECTION

75A35753

UTTL: Ablation of graphite in high-speed air streams  
AUTH: A/SEGLETES, J. A.

Journal of Spacecraft and Rockets, vol. 12, Apr. 1975, p. 251-253.

ABS: An investigation is conducted to study graphite ablation due to convective heat transfer in the high-wall temperature and moderate pressure region where sublimation represents a significant portion of total ablation. This region - referred to as the sublimation regime ranges in wall temperature from about 5000 R to levels that cause graphite to boil. Two ablation models are discussed: a primary model which explicitly accounts for sublimation and a secondary model which implies that sublimation has occurred assuming all species to be in chemical equilibrium at the wall. The correlation between experimental data and analytical results suggests that graphite ablation in the sublimation regime can be explained solely on the basis of thermochemical processes.

MAJS: /\*ABLATIVE MATERIALS/\*AIR FLOW/\*CONVECTIVE HEAT TRANSFER/\*GRAPHITE

75A35221

UTTL: Interaction between a high-speed boundary layer and an inelastic deformable body

AUTH: A/STOCK, H. W.

(Gesellschaft fuer angewandte Mathematik und Mechanik, Wissenschaftliche Jahrestagung, Bochum, West Germany, Apr. 1-5, 1974.) Zeitschrift fuer angewandte Mathematik und Mechanik, vol. 55, Apr. 1975, p. T156-T159. In German.

ABS: In the investigation reported cross hatching is considered to be the result of an interaction between a high-speed boundary layer and an inelastic deformable body surface. This interaction is regarded as a stability problem. A search is conducted of conditions which lead to a surface deformation which increases with time. A theoretical analysis is discussed along with questions concerning the agreement of the conclusions in this analysis with experimental observations. The agreement between theory and experiment is considerable. However, it is not possible to calculate the critical wavelength with this theory.

MAJS: /\*ABLATION/\*AEROTHERMOELASTICITY/\*SUPERSONIC BOUNDARY LAYERS

75A32859

UTTL: Ablative overlays for Space Shuttle leading edge  
ascent heat protection

AUTH: A/SIKAUSS, E. L.  
American Institute of Aeronautics and Astronautics,  
Thermophysics Conference, 10th, Denver, Colo., May  
27-29, 1975. 7 p.

ABS: Ablative overlays were evaluated via a plasma-arc  
simulation of the ascent pulse on the leading edge of  
the Space Shuttle Orbiter. Overlay concepts included  
conformal, polysycyanurate foam, low-density Teflon,  
epoxy, and subliming salts. Their densities ranged  
from 4.9 to 81 lb per cu ft, and the thicknesses  
varied from 0.107 to 0.330 in. Sweet-leading-edge  
models were fabricated from 30-lb per cu ft  
silicone-based ablators. The overlays were bonded to  
maintain the surface temperature of the base ablator  
below 500 F during ascent. Foams provided  
minimum-weight overlays, and subliming salts provided  
minimum-thickness overlays. Teflon left the most  
uniform surface after ascent heating.

MAUS: /-ABLATIVE MATERIALS/-ASCENT TRAJECTORIES/-HEAT  
SHIELDING/-SPACE SHUTTLE ORBITERS/-SPACECRAFT  
SHIELDING

75A32858

UTTL: Innovative casting technique for determining  
heatshield mass loss in an erosive particle  
environment

AUTH: A/SEIDMAN, M. H.; B/CARROLL, D. F.; C/TOY, A.  
American Institute of Aeronautics and Astronautics,  
Thermophysics Conference, 10th, Denver, Colo., May  
27-29, 1975. 10 p.

ABS: An innovative technique has been developed for  
determining the mass loss due to single particle  
impacts in an ablative heatshield material. This  
technique is based on casting an easily molded, high  
density compound into the crater. Then by employing  
both weight differences and X-ray photos of the  
crater, the crater size and characteristic, can be  
determined. This procedure has proven itself  
especially valuable with charred specimens where a  
preheat is employed to obtain high surface  
temperatures, and with specimens, charred or virgin,  
which are impacted at shallow angles. The X-ray photos  
have also been of value in that they delineate the  
crater surface area and depth to an extent that yields  
a correlation with velocity. This latter information  
has been of particular benefit to the determination of  
abscission times, principally at shallow impact  
angles, where the use of mass loss ratios has proven  
inappropriate.

MAUS: /-ABLATIVE MATERIALS/-CASTING/-HEAT SHIELDING/-IMPACT

DAMAGE/-MASS TRANSFER/-REENTRY SHIELDING

75A32857

UTTL: Graphite ablation chemistry nonequilibrium effects  
AUTH: A/BAKER, R. L.  
American Institute of Aeronautics and Astronautics,  
Thermophysics Conference, 10th, Denver, Colo., May  
27-29, 1975. 9 p.

ABS: The implications of the assumption of local solid-gas  
phase equilibrium for subliming carbon species for  
graphite ablation calculations in an air environment  
is investigated. The equilibrium assumption is  
eliminated by considering the Knudsen-Langmuir  
equation at the interface for each carbon species.  
Calculated equilibrium and nonequilibrium results are  
compared for a very wide range of flight and ground  
test environments. The nonequilibrium mass addition  
parameter is always less than the equilibrium value  
and the nonequilibrium wall temperature is always  
larger for a given environment. Calculations made to  
determine the convective heat flux required to reach  
an incipient melt temperature of 3800 K indicate that  
the required flux determined from an equilibrium  
calculation can be too high by as much as 200-300  
percent for stagnation enthalpies less than 5000  
Btu/lb. Calculations for superorbital reentry  
conditions show large differences in the mass addition  
parameter B-prime when the convective heating rate is  
low and the external radiation heating level is  
relatively high.

MAUS: /-ABLATIVE MATERIALS/-AEROTHERMOCHEMISTRY/-GRAPHITE/-  
NONEQUILIBRIUM CONDITIONS/-REENTRY SHIELDING

75A32854

UTTL: Selection of a heat protection system for Venusian  
entry

AUTH: A/BREXER, R. A.  
American Institute of Aeronautics and Astronautics,  
Thermophysics Conference, 10th, Denver, Colo., May  
27-29, 1975. 12 p.

ABS: Carbon phenolic has been selected as the heat shield  
material for the 1978 Pioneer Venus mission since it  
satisfies both the weight and entry science  
requirements better than any other heat shield system.  
Using an Atlas Centaur booster the entry velocity for  
both large and small probes at planet encounter is  
38,000 ft/sec with an entry path angle corridor of  
20-90 deg. The thermal response of the carbon phenolic  
to the combined convective and radiative heat transfer  
rates has been determined by theoretical formulations  
derived specifically for the Venusian atmosphere. Heat  
shield requirements are shown to be relatively

Insensitive to uncertainties in the thermal environment.

MAJS: /•ABLATIVE MATERIALS/•ATMOSPHERIC ENTRY/•CARBON/•HEAT SHIELDING/•PIONEER VENUS SPACECRAFT/•VENUS ATMOSPHERE

75A32775

UTTL: The problem of entry of large meteorites into the atmosphere

AUTH: A/ERENSHTEIN, V. A.  
(Astronomicheskii Vestnik, vol. 8, Oct.-Dec. 1974, p. 193-210.) Solar System Research, vol. 8, no. 4, July 1975, p. 161-175. Translation.

ABS: (For abstract see issue 06, p. 894. Accession no. 475-19219)

MAJS: /•ABLATION/•ATMOSPHERIC ENTRY/•HYPERSONIC HEAT TRANSFER/•METEORIDS/•RADIATIVE TRANSFER/•SHOCK WAVE PROPAGATION

75A32523

UTTL: Characteristics of the disintegration of meteoric bodies of the Taurids

AUTH: A/BABADZHAMOV, P. B.; B/GETMAN, V. S.  
Akademiya Nauk Tadzhikskoi SSR, Dokiady, vol. 17, no. 9, 1974, p. 18-20. In Russian.

ABS: Photographic observations of ten meteors from the Taurids were studied, and on the basis of a previously derived formula (Babadzhamov & Getman, 1972), over 150 values were calculated for the disintegration parameter (ratio of heat transfer to specific energy of mass loss) along the trajectory of each meteor. The dependence of the logarithm of the disintegration parameter on the logarithm of atmospheric density was identical for all objects studied; over the large part of the trajectory, the disintegration parameter decreases with increase of atmospheric density, and increases at the end. The blocking effect of the vaporizing molecules is brought by the data.

MAJS: /•ABLATION/•ASTRONOMICAL PHOTOGRAPHY/•ATMOSPHERIC DENSITY/•METEOROID SHOWERS/•TAURID METEORIDS

75A29811

UTTL: Heat and mass transfer in the flow of a high-enthalpy gas in the air-gas flow area of aircraft and rocket engines

AUTH: A/FATURIN, A. V.; B/KRECHETNIKOV, I. U. D.; C/SEMICHEV, A. I. A.; D/NADYROV, N. A.  
Aviatsionnaya Tekhnika, vol. 18, no. 1, 1975, p. 54-60. In Russian.

ABS: The rate of burnup of the heat-protective coating of an aircraft engine's air-gas flow area is studied analytically. A solution is obtained by integrating

boundary layer equations in which unsteady-state effects caused by chemical erosion of the flow-area surface are taken into account.

MAJS: /•ABLATION/•AIRCRAFT ENGINES/•COMBUSTION CHAMBERS/•HIGH TEMPERATURE GASES/•ROCKET LININGS/•THERMAL CONTROL COATINGS

75A29190

UTTL: Simplified computer model for predicting the ablation of Teflon

AUTH: A/POPE, R. B.

Journal of Spacecraft and Rockets, vol. 12, Feb. 1975, p. 83-88. AEC-supported research.

ABS: This paper describes a computer model of Teflon ablation. The model is constructed from simplified theories and utilizes an existing numerical analysis computer program. The model is used to predict both mass loss and temperature variations during and following aerothermic heating, either in ground-based facilities or in atmospheric flight. Full dense and partial dense Teflons are modeled. Predicted results are verified with available experimental data. The model is used to design a 30X dense heat shield for the base of a typical re-entry vehicle.

MAJS: /•ABLATIVE MATERIALS/•COMPUTERIZED SIMULATION/•NUMERICAL ANALYSIS/•PREDICTION ANALYSIS TECHNIQUES/•REENTRY SHIELDING/•TEFLON (TRADEMARK)

75A29092

UTTL: Transient vibration experiments for determination of properties for viscoelastic structures

AUTH: A/FORRESTAL, M. J.; B/SAGARTZ, M. J.

American Society of Mechanical Engineers, Applied Mechanics Western Conference, University of Hawaii, Honolulu, Hawaii, Mar. 25-27, 1975. 4 p. AEC-supported research.

ABS: Two experimental techniques devised to determine the mechanical properties for viscoelastic structures are demonstrated with experiments on polymethyl methacrylate (PMMA). Circular rings are loaded with an axisymmetric impulse which excites the fundamental

membrane mode and free-free beams are loaded with a spatially distributed impulse which excites the fundamental bending mode. Because only one mode of vibration is excited, these structures can be regarded as single-degree-of-freedom systems in free vibration. Loading is produced by magnetic pressure pulses and the response is measured with strain gages. The complex modulus is obtained from period of vibration and logarithmic decrement of the strain response. Geometry of the specimens is varied to obtain complex moduli over a wide range of frequencies.

MAJS: /•ABLATIVE MATERIALS/•EXPERIMENTAL DESIGN/•MECHANICAL PROPERTIES/•POLYMETHYL METHACRYLATE/•VISCOELASTICITY

75A27027

UTTL: A proposed ablation laser  
AUTH: A/DEYFUS, R. W.; B/WALLACE, S. C.  
Optics Communications, vol. 13, Mar. 1975, p. 218-221.  
ABS: A new type of eximer laser is proposed; it involves the simultaneous sublimation and excitation of a frozen film by means of a relativistic electron beam. Calculated beam requirements for noble gases are about 10 kA per sq cm of 400 kV electrons for periods of 2 to 12 nsec. Predicted advantages of this laser are high gain and the elimination of wavelength limiting optical windows. Preliminary experimental fluorescence spectra have been obtained from xenon films. The emission from the solid phase consists primarily of two 100 Å wide bands centered at 1600 Å and 1730 Å; the fluorescence lifetimes are 4 plus or minus 2 nsec for both bands.

MAJS: /•ABLATION/•ELECTRON IMPACT/•LASER OUTPUTS/•PUMPING/•STIMULATED EMISSION/•SUBLIMATION

75A25585

UTTL: Surface fragmentation of heatproof materials during the ablation process  
AUTH: A/BULANOV, V. N.; B/VASILEV, A. V.; C/FRANTSEVICH, I. N.; D/SHEVCHENKO, V. I.A.  
Akademiia Nauk SSSR, Doklady, vol. 220, Jan. 21, 1975, p. 571-574. In Russian.  
MAJS: /•ABLATIVE MATERIALS/•CARBON FIBER REINFORCED PLASTICS /•FRAGMENTATION/•SURFACE TEMPERATURE/•THERMAL PROTECTION

75A24587

UTTL: Effects of propellant and electrode geometry on pulsed ablative plasma thruster performance  
AUTH: A/PALUMBO, D. J.; B/GURAN, W. J.  
American Institute of Aeronautics and Astronautics, Electric Propulsion Conference, 11th, New Orleans, La., Mar. 19-21, 1975, 8 p.  
AES: A performance level compatible with 30% thrust efficiency at 1500s specific impulse at one millipound of thrust was demonstrated with the parallel rail pulsed ablative thruster using Teflon propellant. Parametric variations of interelectrode spacing and included angle were performed. In addition, Teflon was replaced by other thermoplastics and was also seeded with 10% and 30% LiOH and InBr in an evaluation of alternative propellants. Both the conventional, 'breach-fed' and later side-fed electrode/propellant

configurations were tested. With the same initial conditions it was shown that the breach-fed geometry is more efficient than the side-fed because of the higher specific impulse generated (i.e., up to 5300s using Teflon). Results of these studies indicate that for high thrust/power and moderately high specific impulse, virgin Teflon propellant with an interelectrode spacing of 3.0 inches and zero degree electrode included angle in the side-fed configuration are best.

MAJS: /•ABLATIVE MATERIALS/•ELECTRODES/•PLASMA ENGINES/•PROPELLANT TESTS/•PROPULSION SYSTEM PERFORMANCE/•SPACECRAFT PROPULSION

75A24042

UTTL: Washougal - A stony meteorite with a retrograde orbit  
AUTH: A/CARVER, E. A.; B/ANDERS, E.  
Journal of Geophysical Research, vol. 80, Feb. 10, 1975, p. 789-793.

ABS: The Washougal howardite is alleged to have struck the earth from a retrograde orbit, with a preatmospheric velocity of about 55 km/s. To check this report, we determined the ablation loss of this 0.2-kg meteorite from the angular distribution of cosmic ray tracks, using a new method based on the model of Laurette et al. (1959). The preatmospheric mass was 660 plus or minus 220 kg, which according to meteor theory implies a geocentric velocity of less than about 35 km/s. This upper limit is well below the minimum value for a retrograde orbit, 48 km/s.

MAJS: /•ABLATION/•ATMOSPHERIC ENTRY/•GEOMAGNETISM/•METEORITE COLLISIONS/•ORBITAL ELEMENTS/•STONY METEORITES

75A21273

UTTL: Temperature measurement in a high-temperature carbon multilayer reentry vehicle heatshield  
AUTH: A/WRIGHT, G. F.; JR.; B/BEARD, S. G.; JR.; C/MCVEY, D. F.

In: Advances in thermal conductivity. Proceedings of the Thirteenth International Conference, Lake of the Ozarks, Mo., November 5-7, 1973. (A75-21260 08-23) Rolla, Mo., University of Missouri, 1974, p. 325-331. AEC-USAF-sponsored research.

ABS: A thermal sensor is described that was used in recent carbon/carbon heatshield temperature measurements. The sensor meets stringent requirements on operational temperature range, operational longevity, response to high temperature increase rates, material interface temperature measurement, matching of insulator thermal cross-section, and chemical reaction prevention. A comparison between temperatures measured with the sensor and computed values confirm the material



properties and computational techniques used in the preliminary analysis, as well as demonstrates that the temperature capability of the refractory thermocouples was utilized in a high temperature chemically reactive environment.

MAJS: /•ABLATIVE MATERIALS/•CARBON-CARBON COMPOSITES/•HEAT SHIELDING/•REENTRY VEHICLES/•SPACECRAFT SHIELDING/•TEMPERATURE SENSORS

75A12219

UTTL: Atmospheric entry problem for large meteorites

AUTH: A/BROUSHTEN, V. A.  
Astronomicheskii Vestnik, vol. 8, Oct.-Dec. 1974, p. 193-210. In Russian.

ABS: The various physical phenomena involved in the motion of large meteoric bodies in the atmosphere are discussed. An attempt is made to describe the laws that govern ablation, aerodynamic braking, ionization, heating, and the radiation flux from the compressed air layer behind the forward shock front. It is shown that this radiation flux is the factor primarily responsible for heating and ablation. The dynamics equations of a radiant gas are derived, and methods for calculating hypersonic flows with allowance for radiation are reviewed.

MAJS: /•ABLATION/•ATMOSPHERIC ENTRY/•HYPERSONIC HEAT TRANSFER/•METEORIDS/•RADIATIVE TRANSFER/•SHOCK WAVE PROPAGATION

75A12643

UTTL: Interior ballistics of solid propellant rocket motor with internal burning, cylindrical grain and ablative nozzle

AUTH: A/ERZHISLAV, J.  
International Astronautical Federation, International Astronautical Congress, 25th, Amsterdam, Netherlands, Sept. 30-Oct. 5, 1974, 26 p.

MAJS: /•ABLATIVE MATERIALS/•INTERIOR BALLISTICS/•INTERNAL COMBUSTION ENGINES/•PROPELLANT GRAINS/•ROCKET NOZZLES /•SOLID PROPELLANT ROCKET ENGINES

75A12918

UTTL: Ablation of carbon in a flow at normal and elevated pressures

AUTH: A/GOLGOVINA, E. S.; B/KCIOVA, L. L.  
Heat Transfer - Soviet Research, vol. 6, May-June 1974, p. 166-170. Translation.

ABS: An experimental study is described of ablation of carbon in an argon stream. The carbon consisted of spheres 12 mm in diameter, the argon velocities ranged from 0.5 to 30 m/sec and the temperatures were in the

2800-3500 K range. It was found that ablation of carbon is a three-dimensional process and is affected by the porous structure of the ablator. The experimental data show that raising the pressure to 5 atm reduces the ablation rate markedly whereupon there is no perceptible reduction on further rise in pressure. A design equation is suggested for calculating the ablation rate and it is found to be in satisfactory agreement with experimental data. An expression for obtaining the effective ablation coefficient from experimental data is also given.

MAJS: /•ABLATION/•CARBON/•GAS FLOW/•POROSITY/•PRESSURE EFFECTS

75A12573

UTTL: PERF - A new approach to the experimental study of radiative aerodynamic heating and radiative blockage by ablation products

AUTH: A/WALBERG, G.  
Canadian Aeronautics and Space Institute and American Institute of Aeronautics and Astronautics, Joint Meeting, Toronto, Canada, Oct. 30, 31, 1974, AIAA 12 p.

ABS: The present work describes a facility designed to validate the various aspects of radiative flow field theory, including the absorption of shock layer radiation by ablation products. The facility is capable of producing radiation with a spectrum similar to that of an entry vehicle shock layer and is designed to allow measurements at vacuum ultraviolet wavelengths where the most significant absorption by ablation products is predicted to occur. The design concept of the facility is presented along with results of theoretical analyses carried out to assess its research potential. Experimental data obtained during tests that simulated earth and Venusian entry and in which simulated ablation products were injected into the stagnation region flow field are discussed.

MAJS: /•ABLATION/•AERODYNAMIC HEATING/•ATMOSPHERIC ENTRY SIMULATION/•RADIATION ABSORPTION/•SHOCK LAYERS

75A10865

UTTL: Ablation tests of slip-cast fused silica simulating ballistic reentry

AUTH: A/BURLESON, W. G.; B/LETSON, K. N.  
In: State of radome technology - 1974; Proceedings of the Twelfth Symposium on Electromagnetic Windows, Atlanta, Ga., June 12-14, 1974, (A75-10851 01-04) Atlanta, Georgia Institute of Technology, 1974, p. 77-81.

MAJS: /•ABLATIVE MATERIALS/•ATMOSPHERIC ENTRY SIMULATION/•BALLISTIC MISSILES/•RADOME MATERIALS/•REENTRY

# SHIELDING/SILICON DIOXIDE

75A10860

UTTL: Design properties for three dimensionally reinforced silica  
AUTH: A/PLACE, T. M.  
In: State of radome technology - 1974; Proceedings of the 7th Symposium on Electromagnetic Windows, Atlanta, Ga., June 12-14, 1974. (A75-10851 01-04) Atlanta, Georgia Institute of Technology, 1974, p. 47-51.

ABS: Summary of the results of a study of the mechanical, electrical, and thermophysical characteristics of AS-3CX, a high-purity three-dimensionally reinforced silica composite, developed with the aim of providing a tough refractory dielectric material for use as an ablative reentry antenna window. Its thermophysical and dielectric properties are comparable to those of fused silica.

MAJS: /•ABLATIVE MATERIALS/•RADOME MATERIALS/•REENTRY SHIELDING/•SILICON DIOXIDE/•THREE DIMENSIONAL COMPOSITES

75A10254

UTTL: Kinetic reaction rates for consumption of pyrolytic graphite by combustion gases  
AUTH: A/SCHAEFER, J. W.; B/TONG, H.; C/BEDARD, R. J.  
American Institute of Aeronautics and Astronautics and Society of Automotive Engineers, Propulsion Conference, 10th, San Diego, Calif., Oct. 21-23, 1974, AIAA 13 p

ABS: An experimental program using an arc plasma generator was conducted to determine the kinetic mass consumption rate of pyrolytic graphite in simulated propellant atmospheres. These results, which include a wide range of gas species partial pressures and ablation rates, were successfully correlated using an equation with a functional form determined from phenomenological considerations. These correlations were in turn incorporated as an integral part of a prediction procedure which includes the simultaneous consideration of boundary layer diffusion, equilibrium gas phase chemistry, kinetically controlled surface chemistry, sublimation, in-depth heat conduction, and surface mass-transfer cooling.

MAJS: /•ABLATIVE MATERIALS/•PROPELLANT COMBUSTION/•PYROLYTIC GRAPHITE/•REACTION KINETICS/•ROCKET NOZZLES/•THERMAL PROTECTION

74A46126

UTTL: Cross-hatching studies - A critical review  
AUTH: A/SWIGART, R. J.  
AIAA Journal, vol. 12, Oct. 1974, p. 1301-1318.  
Early experimental studies and phenomenological mechanisms are considered, giving attention to work reported by Canning et al. (1967, 1968), Larson and Mateer (1968), Mirals (1969), Laganelli and Neatler (1969), Laganelli and Zempel (1970), and Williams (1971). Questions concerning the possible relationship between streamwise vortices and cross hatching are explored. It is concluded that streamwise vortices are not necessary for the occurrence of cross hatching. The differential ablation mechanism is also investigated, taking into account studies by Inger (1969, 1970, 1972), work conducted by Conrad et al. (1970), and unsteady approaches to the subliming ablator problem. The liquid layer mechanism is discussed along with a surface deformation mechanism, correlation studies, and experimental results reported by various authors.  
MAJS: /•ABLATION/•SUPERSONIC FLOW/•TURBULENT BOUNDARY LAYER /•TURBULENT HEAT TRANSFER/•VORTICES

74A46101

UTTL: Mechanism of ablation of metals by a supersonic plasma torch in relation to their thermal conductivity  
AUTH: A/AGEEV, V. A.; B/SULTANOV, M. A.  
(Izvestiya Vysokikh Temperatur, vol. 12, Jan.-Feb. 1974, p. 17-23.) High Temperature, vol. 12, no. 1, Sept. 1974, p. 15-20, Translation.  
ABS: (Previously cited in issue 13, p. 1816, Accession no. A74-28759)  
MAJS: /•ABLATION/•METAL PLATES/•PLASMA JETS/•SUPERSONIC HEAT TRANSFER/•THERMAL CONDUCTIVITY

74A45310

UTTL: Interaction of gases with ablative composites. II - Water  
AUTH: A/HONEYCUTT, R. H., III; B/NIGHTMAN, J. P.  
Journal of Applied Polymer Science, vol. 18, 1974, p. 1103-1115.  
ABS: An investigation was conducted to study the sorption of water on two ablative composites and their components as a function of pressure and temperature. A pressure range from 0.001 to 10 torr and a temperature range from 25 to 35 C were considered in the investigation. It was found that the sorption of water vapor by the ablative composites and their components varied directly with pressure. The components of the ablative composites included phenolic spheres, cork, a carbon-glass fiber mixture.

glass spheres, silica fibers, and a silicone elastomer.

MAJS: /•ABLATIVE MATERIALS/•COMPOSITE MATERIALS/•PRESSURE EFFECTS/•SORPTION/•TEMPERATURE EFFECTS/•WATER VAPOR

74A44939

UTTL: Integral technique solutions to a class of simple ablation problems

AUTH: A/VALLERANI, E.

ABS: Meccanica, vol. 9, June 1974, p. 94-101. The 'integral technique' is applied to a class of ablation problems concerning a semiinfinite solid subjected to a heat flux. The governing equations are highly simplified by normalizing the variables with respect to the values obtained at the onset of ablation and by introducing the asymptotic values obtained for large times. The results are discussed in terms of a parameter expressing the ratio of heat capacities between the heat storable in the solid and the latent heat of ablation.

MAJS: /•ABLATION/•ASYMPTOTIC METHODS/•CONDUCTIVE HEAT TRANSFER/•HEAT FLUX/•INTEGRAL TRANSFORMATIONS

74A43466

UTTL: Artificial meteor ablat on studies - Olivine

AUTH: A/BLANCHARD, M. B.; B/CUMMINGS, G. G.

Journal of Geophysical Research, vol. 79, Sept. 10, 1974, p. 3973-3980.

ABS: Artificial meteor ablation has been performed on a Mo-rich olivine sample by means of an arc-heated plasma of ionized air. Experimental conditions simulated a meteor traveling about 12 km/sec at an altitude of 70 km. The mineral content of the original olivine was 98% olivine (including traces of olivine alteration products) and 2% chromite. The forsterite content of the original olivine was 89 and increased to 94 in the recrystallized olivine after ablation. In addition, lamella-like intergrowths of magnetite were prevalent. Wherever magnetite occurred, Mo increased and Fe decreased in the recrystallized olivine. The Fe for the magnetite exsolved from the original olivine crystals. Individual particles (i.e., spherules) were also characterized by magnetite intergrowths. Fusion crusts on the Allende and Murchison meteorites were compared with the fusion crust on the olivine sample. The Allende fusion crust consisted of a recrystallized olivine, richer in Mg and deficient in Fe in comparison with the original meteorite's olivine, and abundant magnetite grains.

MAJS: /•ABLATION/•METEORITIC COMPOSITION/•OLIVINE/•SPACE ENVIRONMENT SIMULATION

74A42385

UTTL: Influence of a critical parameter on development of an advanced ablative

AUTH: A/MUKHERJEE, M. K.; B/SARKAR, B. K.; C/GOVINDARAJU, K.

In: International Symposium on Space Technology and Science, 10th, Tokyo, Japan, September 3-8, 1973. Proceedings. (A74-42352 21-31) Tokyo, AGNE Publishing, Inc., 1973, p. 337-346.

ABS: In order to study the properties of advanced ablatives, two types of conventional ablatives were selected: (1) an asbestos-epoxy system and (2) an asbestos-phenolic system. Both were coated with a Co alloy by an electrolytic method. The specimens with various coating time were tested with an oxy-acetylene torch burner, and the erosion rate was determined. The advanced ablatives thus developed by varying the W-Co coating time were found to have an effectively reduced erosion rate. The role played by the various variables, such as resin, reinforcements, fabrication method, environmental conditions, etc. are briefly discussed. Finally, the possibility of using these W-Co alloy coated materials for thermal protection of nozzle and other relevant rocket component like nose cone, etc. is discussed.

MAJS: /•ABLATIVE MATERIALS/•ASBESTOS/•EPOXY RESINS/•HEAT SHIELDING/•METAL COATINGS/•PHENOLIC RESINS

74A40241

UTTL: Nonequilibrium boundary layer at a stagnation point: for a hydrogen-helium stream over ablating graphite

AUTH: A/LIU, T.-M.; B/DAVY, W. C.

ABS: Acta Astronautica, vol. 1, Mar.-Apr. 1974, p. 485-503. The nonequilibrium axisymmetric stagnation point boundary layer over an ablating graphite surface is considered. The external stream is a high temperature mixture of hydrogen and helium. Variable thermodynamic and transport properties are assumed. Lennard-Jones potential model is used to calculate the transport coefficients of each species. Although the mixture rules for viscosity of the gas mixture are used, the weighting functions are more sophisticated than those commonly employed. For the conductivity of the mixture, generalized Wassiljewa coefficients are used. Seven species with 28 dissociation/recombination reactions are considered. Hansen's model for the dissociation rate constants is employed. The recombination rate constants are obtained by invoking detailed balance principles assisted by the JANAF thermodynamic data and the Hansen-Pearson thermodynamic data for C<sub>3</sub>.

MAJS: /•ABLATIVE MATERIALS/•BOUNDARY LAYER STABILITY/•GAS MIXTURES/•HEAT SHIELDING/•NONEQUILIBRIUM FLOW/•

# STAGNATION POINT

74A40208

UTTL: Performance of ablator materials in ramjet environments

AUTH: A/COHEN, L. S.; B/COUCH, H. T.; C/MURRIN, T. A.  
American Institute of Aeronautics and Astronautics and American Society of Mechanical Engineers.  
Thermophysics and Heat Transfer Conference, Boston, Mass., July 15-17, 1974. AIAA 18 p.

ABS: The principal goal is to identify suitable ablative materials for use in the ramjet case and nozzle regions for the most demanding environments attainable during present and anticipated future missions, on the basis of pertinent experiments and supporting analytical tasks. In the conduct of the work, combustor blast tubes and nozzles molded from various candidate ablative formulations were instrumented with in-depth thermocouples and tested in a subscale vitiation reactor facility to provide material performance data. The Charring Material Ablation (CMA) computerized analysis (Moyer and Rindal, 1967) was applied to the prediction of the in-depth temperature profiles and char formation rates for comparison with the test observations. Good agreement of theory with data is achieved with the use of a char conductivity which is taken as the true conductivity normalized by the swell factor.

MAJS: /•ABLATIVE MATERIALS/•COMBUSTION CHAMBERS/•PERFORMANCE TESTS/•RAMJET ENGINES/•THERMAL INSULATION

74A35409

UTTL: Ablation stability of laser-driven implosions

AUTH: A/HERSCOVITZ, D. B.; B/ROGERS, R. L.; C/MORSE, R. L.  
Physical Review Letters, vol. 33, July 22, 1974, p. 205-208. AEC-sponsored research.

ABS: Perturbation analysis of the stability of ablative, laser-driven implosions of homogeneous spherical pellets shows stability of the ablation surface, a necessary condition for achieving the high densities required for laser fusion. This conclusion is supported by physical arguments.

MAJS: /•ABLATION/•IMPLOSIONS/•LASER HEATING/•PELLETS/•SURFACE STABILITY

74A36053

UTTL: Development of an aeroballistic range capability for testing reentry materials

AUTH: A/NORFLEET, G. D.; B/HENDRIX, R. E.; C/RAPER, R. M.; D/CALLENS, E. E., JR.  
American Institute of Aeronautics and Astronautics.

Aerodynamic Testing Conference, 8th, Bethesda, Md., July 8-10, 1974, 12 p.

ABS: Concentrated efforts in such areas as model launching techniques, test environment simulation, and specialized instrumentation have resulted in the emergence of the AEDC-VKF 1000-ft Hyperballistic Range (G) as a viable and versatile facility for testing reentry materials. Its launch capability, long flight length, variable pressure capability, specialized instrumentation, and capability to provide several types of erosive test environments (e.g., rain, dust, snow) make Range G well suited for ablation, erosion, and heat-transfer testing. Eight laser photographic systems and three image-converter camera photocyrometry systems provide in-flight measurements of nose-tip recession and surface temperature.

MAJS: /•ABLATIVE MATERIALS/•BALLISTIC RANGES/•ENVIRONMENT SIMULATION/•ENVIRONMENTAL TESTS/•REENTRY EFFECTS/•TEST FACILITIES

74A35941

UTTL: Experimental surface and boundary layer measurements in a hypersonic boundary layer with non-uniform blowing

AUTH: A/LAGANELLI, A. L.; B/MARTELLUCCI, A.  
American Institute of Aeronautics and Astronautics and American Society of Mechanical Engineers.  
Thermophysics and Heat Transfer Conference, Boston, Mass., July 15-17, 1974. AIAA 8 p.

ABS: An experimental program has been conducted utilizing a transpiration cooling system to simulate ablation effects relative to the behavior of dissimilar materials in a reentry environment. For this situation, ground and flight tests have shown that a necking occurs downstream of the region of material discontinuity which is believed to be a result of this differential ablation process. It was found that a step-up in blowing causes a local disturbance on the boundary layer characteristics and a subsequent change on the local properties yielding increases in both heat transfer and pressure.

MAJS: /•ABLATION/•ATMOSPHERIC ENTR• SIMULATION/•BLOWING/•HYPERSONIC BOUNDARY LAYER/•SWEAT COOLING

74A35940

UTTL: Integral solution for thermal performance of a charring ablator

AUTH: A/LAGANELLI, A. L.; B/HARPER, T. P.; C/FOGAROLI, R. P.

American Institute of Aeronautics and Astronautics and American Society of Mechanical Engineers.  
Thermophysics and Heat Transfer Conference, Boston.

Mass., July 15-17, 1974. AIAA 8 P.

**ABS:** An engineering solution has been developed that minimizes computer cost and time consumption in performing studies of the complex problem of coupled conduction-ablation of reentry heat shields. The method features closed-form solutions resulting from the Goodman integral technique for char-forming carbonaceous heat shield materials. Both polynomial and exponential temperature profiles are employed in this technique which is then compared to a sophisticated finite-difference technique. Surface recession and temperature compare quite favorably and the in-depth response is predicted adequately. In all cases the exponential profile approximation yielded the best agreement with the finite difference solution.

**MAJS:** /\*ABLATIVE MATERIALS/\*FINITE DIFFERENCE THEORY/\*PERFORMANCE PREDICTION/\*REENTRY SHIELDING/\*THERMAL DEGRADATION

74A35834

**UTTL:** Development of external protection materials for cryogenic tanks

**AUTH:** A/MACALOUS, J. W.; B/THOMAS, D. A.  
In: New Industries and applications for advanced materials technology: Proceedings of the Nineteenth National Symposium and Exhibition, Buena Park, Calif., April 23-25, 1974. (A74-35788 17-18) Azusa, Calif., Society for the Advancement of Material and Process Engineering, 1974. p. 534-541.

**ABS:** Procedures for the application of cryogenic/ablative material systems to an aluminum substrate have been evolved. The systems include both cryogenic foam over ablative and ablative over cryogenic foam materials. Material systems evaluated in this effort include: a honeycomb core reinforced elastomeric ablator, newly developed sprayable ablative compositions, sprayable polyurethane foams, and, for special areas, an 'in-situ' polyurethane foam material. Limited physical properties were determined for selected materials and are reported. The feasibility of several insulative/ablative approaches involving different applications procedures was verified.

**MAJS:** /\*ABLATIVE MATERIALS/\*CRYOGENICS/\*FUEL TANKS/\*PROTECTIVE COATINGS/\*THERMAL INSULATION

74A35319

**UTTL:** The effect of weave spacing on the properties of 3D orthogonal carbon-carbon composites

**AUTH:** A/ROWE, C. R.  
In: New Industries and applications for advanced materials technology: Proceedings of the Nineteenth

National Symposium and Exhibition, Buena Park, Calif., April 23-25, 1974. (A74-35788 17-18) Azusa, Calif., Society for the Advancement of Material and Process Engineering, 1974. p. 359-373.

**ABS:** Two types of carbon-carbon composites with various weave spacings were evaluated to determine the effect of the weave variables on the properties of these composite materials. Thermal/mechanical, ablation, and microstructural properties were determined. Data and photomicrographs are presented that support the conclusions drawn about weaving, processing, thermal/mechanical properties, ablation performance, and microstructural features.

**MAJS:** /\*ABLATIVE MATERIALS/\*CARBON-CARBON COMPOSITES/\*FIBER ORIENTATION/\*FILAMENT WINDING/\*MECHANICAL PROPERTIES/\*THREE DIMENSIONAL COMPOSITES

74A35377

**UTTL:** Prospects for an ablation/erosion facility employing the PHEA concept

**AUTH:** A/JOHNSON, E. G.; B/MACDERMOTT, W. N.; C/KESEEL, P. A.

American Institute of Aeronautics and Astronautics. Aerodynamic Testing Conference, 8th, Bethesda, Md., July 8-10, 1974. 10 p. USAF-sponsored research.

**ABS:** Recent research findings on problems identified with the RHEA (Reentry Heating Energies Analyzer) multi-component flow process as proposed by the Air Force Aerospace Research Laboratories have been encouraging. This paper discusses some of these results and proposes designs for an experiment to demonstrate a combined ablation/erosion application for a reentry body test facility development program. A feasibility study, based on light gas acceleration of particles and injections into an arc-heated ablation flow, was analyzed in detail, and an experimental effort was undertaken. Initial performance of this facility is expected to combine state-of-the-art ablation capability in an arc-heated air flow with erosion from 4000- to 5000-ft/sec particles accelerated in a helium expansion nozzle. Future use of hydrogen in the acceleration nozzle is projected to increase particle velocities to 10,000-12,000 ft/sec.

**MAJS:** /\*ABLATION/\*EROSION/\*REENTRY EFFECTS/\*TEST FACILITIES

74A33711

**UTTL:** The effect of departures from classical meteor ablation theory on the incident flux of shower meteors deduced from radio-echo observations

**AUTH:** A/POOLE, L. M. G.  
Royal Astronomical Society, Monthly Notices, vol. 163.

no. 1, 1973, p. 129-139.

MAJS: /\*ABLATION/\*METEOR TRAILS/\*METEOROID SHOWERS/\*RADIO ECHOES/\*RADIO METEORS

74A33225

UTTL: Interaction of gases with ablative composites. I - Ar, CO<sub>2</sub>, and N<sub>2</sub>

AUTH: A/KING, C. A.; B/WIGHTMAN, J. P.  
Journal of Applied Polymer Science, vol. 18, 1974, p. 505-519.

ABS: The sorption of argon, carbon dioxide, and nitrogen on two heat shield composites (SLA-561 and SLA-561V) and on the SLA components was measured over the pressure range of 0.001 to 760 torr and in the temperature range of 30 to 50 C. The sorption of the gases by both the composites and the components varied directly with pressure. The sorption of CO<sub>2</sub> by the phenolic spheres and the silicone elastomer and of Ar by the silicone elastomer varied inversely with temperature. The mechanism involved in the gas sorption was primarily absorption.

MAJS: /\*ABLATIVE MATERIALS/\*COMPOSITE MATERIALS/\*GAS-SOLID INTERFACES/\*HEAT SHIELDING/\*SORPTION

74A33114

UTTL: Ablation of ceramic and metallic heat shields

AUTH: A/ZIERING, M.  
American Institute of Aeronautics and Astronautics, Fluid and Plasma Dynamics Conference, 7th, Palo Alto, Calif., June 17-19, 1974, 17 p.

ABS: Simplified thermochemical ablation models are developed for several ceramic and metallic heat-shield materials, potentially useful as high-performance reentry nose tips. The models are based on phase equilibrium at the ablating surface and on the simplified film-coefficient approach for unity Lewis-Scavency number. Limited test data from the Avco Model 500 arc and elsewhere are compared with the predictions based on equilibrium thermochemistry, and discrepancies are discussed and explained. The thermochemical models are used to compare the ablative performance of these materials in a typical high-performance nosetip environment, and the most attractive materials, from this standpoint, are identified

MAJS: /\*ABLATIVE MATERIALS/\*CERAMICS/\*HEAT SHIELDING/\*METAL SURFACES/\*NOSES (FOREBODIES)/\*REENTRY SHIELDING

74A32555

UTTL: Influence of ablation impurities on blunt body re-entry ionization

AUTH: A/SCHEXNAYDER, C. J., JR.; B/EVANS, J. S.

ABS: AIAA Journal, vol. 12, June 1974, p. 805-811.  
Electron density profiles which include the effect of an ablated sodium impurity were computed for the boundary layer on a blunt-nosed body re-entering the atmosphere at 7.62 km/sec. Profiles are computed from the nose to a distance of four diameters along the RAM C-payload. A finite-difference, laminar, nonequilibrium chemistry boundary-layer program was used. Comparison of theory with S-band diagnostic antenna results, electron concentration deduced from X- and C-band attenuation data, and Langmuir probe data at several different aft body locations show that agreement is good at high altitude. At the lower altitudes there is disagreement between theory and S-band antenna data where the apparent discrepancy is attributed to the three-body recombination rate constant used for deionization of sodium coupled with the effect of angle of attack.

MAJS: /\*ABLATION/\*ATMOSPHERIC IONIZATION/\*BLUNT BODIES/\*ELECTRON DENSITY PROFILES/\*LAMINAR BOUNDARY LAYER/\*REENTRY EFFECTS

74A28755

UTTL: The ablation mechanism of metals acted upon by a supersonic plasma torch as a function of their heat conductivity

AUTH: A/AGEEV, V. A.; B/SULTANOV, M. A.

Teplofizika Vysokikh Temperatur, vol. 12, Jan.-Feb. 1974, p. 17-23. In Russian.

MAJS: /\*ABLATION/\*METAL PLATES/\*PLASMA JETS/\*SUPERSONIC HEAT TRANSFER/\*THERMAL CONDUCTIVITY

74A26836

UTTL: Performance studies of a low power ablation plasma thruster

AUTH: A/LIEBING, L.; B/SEIDEL, F.

In: Electric propulsion of space vehicles: Proceedings of the Conference, Abingdon, Berks., England, April 10-12, 1973. (A74-26801 11-28) Stevenage, Herts., England, Institution of Electrical Engineers, 1973, p. 201-206.

ABS: A low-power ablation plasma thruster described by Liebing and Seidel (1972) was modified to eliminate unstable ablation of the fuel rod and severe erosion of the cathode. The original and modified versions of the plasma accelerator are examined, and endurance-test data obtained with the modified version are discussed.

MAJS: /\*ABLATION/\*PERFORMANCE TESTS/\*PLASMA ACCELERATORS/\*  
PLASMA ENGINES/\*SOLID PROPELLANTS

74A26481

UTTL: Instrumentation for an aeroballistic range ablation  
test facility

AUTH: A/HENDRIX, R. E.; B/DUGGER, P. H.  
In: ICIAAF '73; International Congress on  
Instrumentation in Aerospace Simulation Facilities,  
5th, Pasadena, Calif., September 10-12, 1973, Record,  
(A74-26476 11-11) New York, Institute of Electrical  
and Electronics Engineers, Inc., 1973, p. 45-50.

ABS: Concentrated efforts in such areas as model  
development, instrumentation, and data reduction have  
been applied at the Arnold Engineering Development  
Center (AEDC) Hyperballistic Range G, and this  
facility has emerged as a viable and very versatile  
aerospace test unit. Range G is especially well suited  
for ablation testing because of its launch capability,  
its long flight length, its variable pressure  
capability, and its specialized instrumentation. Laser  
photographic systems and photographic pyrometry  
systems are described. These systems have played a  
major role in the successful conduct of ablation  
testing in Range G.

MAJS: /\*ABLATION/\*BALLISTIC RANGES/ HYPERVELOCITY  
PROJECTILES/\*LASERS/\*SHADOWGRAPH PHOTOGRAPHY/\*  
TEMPERATURE MEASUREMENT

74A25021

UTTL: Spectroscopic investigations concerning the wake of  
ablating models of hypersonic vehicles

AUTH: A/RACH, H.  
Raumfahrtforschung, vol. 18, Jan.-Feb. 1974, p. 1-9.  
In German.

ABS: In the hyperballistic range of ISL models of various  
materials were launched into air with velocities from  
4000 to 6500 m/s at pressures between 0.01 and 1.5  
bar. Thus it was possible to simulate reentry  
phenomena. In the wake of the projectiles the  
radiation emitted as a result of the ablation was  
measured and the distribution of both temperature and  
concentration of specific ablation products was  
determined by means of spectroscopy.

MAJS: /\*ABLATION/\*HYPERSONIC REENTRY/\*HYPERSONIC VEHICLES/\*  
HYPERSONIC WAKES/\*SPACECRAFT MODELS/\*SPECTROSCOPIC  
ANALYSIS

74A23479

UTTL: Dependence of meteor parameters on the fragmentation  
process in meteor bodies

AUTH: A/SIMCENKO, A. N.

ABS: Meteoritika, no. 32, 1973, p. 43-49. In Russian.  
Ablation parameters, fragmentation indices, and  
apparent densities of meteors produced by  
fragmentation of parent meteor bodies are discussed in  
relation to various types of fragmentation processes,  
such as splitting into equal or unequal fragments,  
splitting of all fragments or a portion of fragments  
in a continuous fragmentation process, and a  
quasi-continuous separation of small fragments. It is  
shown that the brightness curve of a meteor undergoing  
fragmentation gives information for determining the  
type of fragmentation.

MAJS: /\*ABLATION/\*BOLIDES/\*BRIGHTNESS/\*FRAGMENTATION/\*METEOR  
TRAILS/\*METEORIDS

74A22307

UTTL: Experimental study of the processes of unsteady heat  
and mass transfer between reacting bodies and a heated  
gas flow

AUTH: A/ABALTUSOV, V. E.; B/ISAKOV, G. N.  
Fizika Goreniia i Vzryva, vol. 9, Nov.-Dec. 1973, p.  
807-812. In Russian.

ABS: Consideration of the processes occurring during  
unsteady heating, ignition, and entrainment  
(combustion) of textile (a cooking heat-shielding  
material) in oxygen and atmospheric air oxidizers. It  
is shown that, depending on conditions, the ignition  
time can either increase or decrease with an increase  
in the incident (oxidizer) flow rate. In particular,  
it is shown that at Damkoehler numbers less than a  
certain critical number a regime is observed in which  
an increase in the incident flow rate decreases the  
ignition time. At Damkoehler numbers above the  
critical number, on the other hand, an increase in the  
flow rate increases the ignition time.

MAJS: /\*ABLATIVE MATERIALS/\*GAS HEATING/\*HEAT SHIELDING/\*  
HEAT TRANSFER/\*IGNITION LIMITS/\*MASS TRANSFER

74A22306

UTTL: Some problems in studying the ablative disintegration  
of high-polymer based thermal protection coatings

AUTH: A/SHVAB, V. A.; B/LOSHKAREV, V. A.  
Fizika Goreniia i Vzryva, vol. 9, Nov.-Dec. 1973, p.  
800-807. In Russian.

MAJS: /\*ABLATION/\*ABLATIVE MATERIALS/\*HIGH POLYMERS/\*PLASTIC  
COATINGS/\*PROTECTIVE COATINGS/\*THERMAL PROTECTION

74A22107

UTTL: A review of processable high temperature resistant addition-type laminating resins  
AUTH: A/SERAFINI, T. T.; B/DELVIGS, P.

In: Polymeric materials for unusual service conditions; Proceedings of the Conference, Moffett Field, Calif., November 29-December 1, 1972. (A74-22101 08-18) New York, Wiley-Interscience, 1973, p. 63-100.

ABS: An important finding that resulted from research that was conducted to develop improved ablative resins was the discovery of a novel approach to synthesize processable high temperature resistant polymers. Low molecular weight polyimide prepolymers end-capped with norbornene groups were polymerized into thermooxidatively stable modified polyimides without the evolution of void producing volatile materials. This paper reviews basic studies that were performed using model compounds to elucidate the polymerization mechanism of the so-called addition-type polyimides. The fabrication and properties of polyimide/graphite fiber composites using A-type polyimide prepolymer as the matrix are described. An alternate method for preparing processable A-type polyimides by means of in situ polymerization of monomeric reactants on the fiber reinforcement is also described.  
polyimide/graphite fiber composite performance at elevated temperatures is presented for A-type polyimides.

MAJS: /\*ABLATIVE MATERIALS/\*ADDITION RESINS, \*CARBON FIBER REINFORCED PLASTICS/\*POLYIMIDE RESINS/\*THERMAL RESISTANCE

74A20297

UTTL: Biot's variational principle for aerodynamic ablation of melting solids

AUTH: A/PRASAD, A.; B/AGRAWAL, H. C.

ABSTRACT: AIAA Journal, vol. 12, Feb. 1974, p. 250-252. Extension of the applicability of Biot's (1962) method of variational analysis of ablation of melting bodies involving a heat flux at the boundary that is generated aerodynamically. The applicability to phase-change problems with aerodynamic heating is demonstrated, and simplicity and accuracy are shown to be the method's advantages.

MAJS: /\*ABLATION/\*AERODYNAMIC HEAT TRANSFER/\*BIOT METHOD/\*MELTING/\*RECTRY EFFECTS/\*VARIATIONAL PRINCIPLES

74A19475

UTTL: Influence of a Teflon ablative lining on the specific impulse of rocket engines  
AUTH: A/CHIESI, F.; B/GISMONDI, E.

In: Istituto Internazionale delle Comunicazioni, Convegno Internazionale delle Comunicazioni, 21st., Genoa, Italy, Oct. 8-13, 1973, Paper, 20 p. In Italian.

ABS: In these notes are discussed the experimental results obtained on a rocket engine with combustion chamber covered by Teflon, showing, in particular, how, with suitable mixture ratios, it is possible to obtain a specific impulse quite superior to that given by liquid-cooled engines. The propellants used are oxygen and kerosene. Teflon, used as coating, acts also as a good combustible agent; therefore, its weight is calculated in the global balance weight of propellants.

MAJS: /\*ABLATIVE MATERIALS/\*PLASTIC COATINGS/\*ROCKET ENGINES /\*ROCKET LININGS/\*SPECIFIC IMPULSE/\*TEFLON (TRADEMARK)

74A17104

UTTL: Mass transfer cooling

AUTH: A/HARNETT, J. P.

In: Handbook of heat transfer. (A74-17085 05-33) New York, McGraw-Hill Book Co., 1973, p. 17-1 to 17-63. Formulas and graphs are used to describe the flow parameters and heat transfer mechanisms in mass transfer cooling schemes based on transpiration cooling, gas film cooling, liquid film cooling, and ablation cooling. Forced and free-convection laminar and turbulent flow conditions for transpiration cooling are examined along with various injection conditions in gas film cooling.

MAJS: /\*ABLATION/\*FILM COOLING/\*GAS COOLING/\*LIQUID COOLING /\*MASS TRANSFER/\*SWEAT COOLING

74A17103

UTTL: Ablation

AUTH: A/HURWICZ, H.; B/ROGAN, J. E.

In: Handbook of heat transfer. (A74-17085 05-33) New York, McGraw-Hill Book Co., 1973, p. 16-1 to 16-54. Heat and mass transfer phenomena occurring in the ablation process are described, with emphasis placed on hypersonic flight. Various regimes involved in ablation are explained in terms of mass removal caused by thermochemical and mechanical processes, the response of the material to the environment, the mechanisms by which the material absorbs heat, boundary layer phenomena, and mass and energy balance at the surface. A comprehensive review is given of currently employed mathematical treatments of the



thermochemical response of ablators which are surface coupled to a hypersonic, compressible, reacting, viscous flow field with a possibility of mass injection.

MAJS: /•ABLATION/•BOUNDARY LAYER FLOW/•HEAT TRANSFER/•  
HYPERSONIC FLIGHT/•MASS TRANSFER/•THERMOCHEMICAL  
PROPERTIES

74A17032

UTTL: Char formation in ablatives  
AUTH: A/RASHTOGI, R. P.; B/DEEPAK, D.  
AIAA Journal, vol. 12, Jan. 1974, p. 114-116.  
Research supported by the Council of Scientific and  
Industrial Research of India.

ABS: The chemistry of char formation by decomposition of  
ablative heat shields is studied on the basis of bond  
energy considerations and the nature of the  
decomposition products. Char formation on heating  
polymers is shown to be the result of thermal  
degradation of polymers at high temperatures in a  
specific environment. Initially, on pyrolysis, free  
radicals are formed; further chain cleavage is  
propagated when a free radical gives off a hydrogen  
atom, initiating reaction. Chain termination occurs  
when two free radicals combine to form a neutral  
species. Data on some typical ablative and the bond  
energies of the bonds involved are tabulated. From  
these tables, it follows that a good ablative should  
have a high carbon content and a low oxygen percentage  
in order to minimize the formation of CO and CO<sub>2</sub>, and  
thus conserve carbon in the solid state.

MAJS: /•ABLATIVE MATERIALS/•CHARRING/•CHEMICAL BONDS/•HEAT  
SHIELDING/•THERMAL DISSOCIATION

74A16721

UTTL: Modeling sublimation of a charring ablator  
AUTH: A/BALHOFF, J. F.; B/PIKE, R. W.  
Journal of Spacecraft and Rockets, vol. 10, Dec. 1973,  
p. 822-824.

ABS: The Hertz-Knudsen analysis is shown to accurately  
predict the sublimation rate from a charring ablator.  
Porosity is shown to have a significant effect on the  
surface temperature. The predominant carbon species  
found in the vapor is C<sub>3</sub>, which agrees well with the  
results of previous investigations.

MAJS: /•ABLATIVE MATERIALS/•CARBON/•CHARRING/•HEAT SHIELDING  
/•SUBLIMATION

74A16714

UTTL: Conditions for stability of an ablating symmetric  
rolling re-entry vehicle  
AUTH: A/KADUSHIN, I.  
Journal of Spacecraft and Rockets, vol. 10, Dec. 1973,  
p. 808-811.

ABS: A conservative estimate is obtained on the time lag  
during which the motion of an ablating symmetric  
rolling reentry vehicle is stable. Liepunov's function  
is used to obtain a differential inequality to which  
the comparison principle is applied. By this method  
the desired stability criterion is obtained.

MAJS: /•ABLATION/•LATERAL CONTROL/•REENTRY EFFECTS/•  
SPACECRAFT STABILITY

74A15712

UTTL: Similarity analysis for the surface ablation of  
silica-reinforced composites  
AUTH: A/HSIEH, C.-L.; B/SEADER, J. D.  
Journal of Spacecraft and Rockets, vol. 10, Dec. 1973,  
p. 797-802.

ABS: The ablation mechanism of a silica-reinforced  
composite is approximated as a problem involving a  
two-phase laminar boundary-layer melt flow with  
heterogeneous chemical reaction. A model of mixture  
flow is used to simplify the governing equations,  
which are converted into a set of ordinary  
differential equations via similarity transforms. The  
technique of quasilinearization is utilized to attack  
this coupled boundary-value problem. It is found that  
this numerical procedure can converge rapidly to the  
true solution, if the dimensionless variables and the  
boundary conditions are properly defined. This is  
achieved by analyzing the physical nature of the  
ablation mechanism and the stability and convergence  
characteristics of the governing equations. The  
strategy of matching the interface conditions of the  
molten layer and the gas-boundary layer is also  
developed, after the solution of the gas  
boundary-layer flow is analyzed.

MAJS: /•ABLATIVE MATERIALS/•BOUNDARY LAYER FLOW/•LAMINAR  
BOUNDARY LAYER/•REINFORCED PLASTICS/•SILICON DIOXIDE/•  
TWO PHASE FLOW

74A16705

UTTL: Meteoric aerosols  
AUTH: A/LINK, F.

La Recherche Spatiale, vol. 12, Nov.-Dec. 1973, p.  
25-27. In French.

AB: It is evident that meteoric aerosols should exist in  
the terrestrial atmosphere as the product of ablation  
of shooting stars and further, under the form of

cosmic dusts (micrometeorites). Given the extensive pollution of the lower atmosphere by aerosols of terrestrial origin, the detection of meteoric aerosols appears easier in the upper atmosphere, at the source itself of meteoric accretion. Some results obtained in France by the method of optical detection are reviewed. This method, which avoids the very costly necessity of measurements in situ is at the same time very sensitive and execution is easy. It is based on the diffusion of light produced by meteoric aerosols during twilight.

MAJS: /•ABLATION/•AEROSOLS/•LIGHT SCATTERING/•  
MICROMETEORIDS/•TWILIGHT GLOW/•UPPER ATMOSPHERE

74A14737

UTTL: Silicone materials for the 70s

AUTH: A/TUMBRINK, L. M.

In: Materials and processes for the 70's - Cost effectiveness and reliability. Proceedings of the Fifth National Technical Conference, Klamath Lake, N.Y., October 9-11, 1973. (A74-14730 03-15) Azusa, Calif.: Society for the Advancement of Material and Process Engineering, 1973. p. 63-70.

ABS: Appraisal of some new silicone materials as to their applicability in challenging environments. The materials include advanced fluorosilicone elastomers designed for various harsh environments; phenylmethyl materials designed for high-temperature and high-shear ablative environments and also for low-temperature applications; and controlled-volatility materials with low creasing levels under extreme vacuum conditions.

MAJS: /•ABLATIVE MATERIALS/•ENVIRONMENTAL ENGINEERING/•  
FLUORO COMPOUNDS/•SILICONES/•VACUUM EFFECTS

74A12531

UTTL: Solid motor aft closure insulation erosion

AUTH: A/STAMPEL, E.; B/LANDSBAUM, E. M.

American Institute of Aeronautics and Astronautics and Society of Automotive Engineers, Propulsion Conference, 9th, Las Vegas, Nev., Nov. 5-7, 1973. AIAA 12 p.

ABS: The erosion rate of aft closure insulation in a number of large solid propellant motors was empirically analyzed by correlating the average ablation rate with a number of variables that had previously been demonstrated to affect heat flux. The main correlating parameter was a heat flux based on the simplified Bartz heat transfer coefficient corrected for two-dimensional effects. A multiplying group contained terms related to port-to-throat ratio, local wall angle, grain geometry and nozzle cant angle. The resulting equation gave a good correlation and is a

useful design tool.

MAJS: /•ABLATIVE MATERIALS/•EROSION/•HEAT FLUX/•ROCKET  
ENGINE DESIGN/•SOLID PROPELLANT ROCKET ENGINES

74A12429

UTTL: Motion of a fragment in a disturbed atmosphere behind a meteoric body

AUTH: A/PADEVET, V.

Astronomical Institutes of Czechoslovakia. Bulletin.

vol. 24, no. 5, 1973. p. 283-290.

ABS: The effect of atmospheric flow disturbances behind the main body of a meteor on the motion and ablation of fragments of the main body is examined together with possible differences which could result between photometric and dynamic mass determinations for the meteor. It is shown that small cold fragments ablated from the main body could be transported to large distances in the atmosphere without significant heating if certain assumptions are made about atmospheric wake disturbances. A realistic model of the flowfield behind the main meteor could explain differences between dynamically and photometrically computed meteor masses even if chondritic meteor densities are employed.

MAJS: /•ABLATIVE MATERIALS/•ATMOSPHERIC TURBULENCE/•DYNAMIC  
CHARACTERISTICS/•METEORIDS/•SPACE DEBRIS/•TURBULENT  
WAKES

74A11279

UTTL: High-temperature properties and failure criteria for rocket nozzle materials

AUTH: A/VICARIO, A. A., JR.; B/FREEMAN, W. T., JR.;

C/CASEDAY, E. D.

American Institute of Aeronautics and Astronautics and Society of Automotive Engineers, Propulsion Conference, 9th, Las Vegas, Nev., Nov. 5-7, 1973. AIAA 12 p.

ABS: The adaptation of anisotropic failure criteria along with the availability of high-temperature material property represents a new approach to the prediction of structural integrity in rocket nozzles. Strength, modulus, and elongation data in tension, compression, and shear, and coefficient of thermal expansion data were obtained at temperatures up to 4000 F for five nozzle materials. Several failure criteria were investigated, using off-axis compression specimens as initial screening tests. Modification of one of the distortion energy criteria appears to be a promising approach for the prediction of the structural integrity of some of these materials at elevated temperatures and combined loading.

MAJS: /•ABLATIVE MATERIALS/•FAILURE ANALYSIS/•HIGH

# TEMPERATURE TESTS/-ROCKET NOZZLES

74A10998

UTTL: Experimental study of the thermal degradation of an ablative material  
 AUTH: A/JANET, J.; B/JALIN, R.; C/LETOURNEUR, C.  
 la Recherche Aerospatiale, July-Aug. 1973, p. 233-244.  
 In French.  
 ABS: Studies carried out on the chemical and thermal kinetics of reinforced plastics within a temperature range from ambient to 1900 C are discussed. Two recent methods utilized between 20 and 1000 C to determine thermal diffusivity by laser flash, and the kinetics of gaseous species formation by mass spectrometry during pyrolysis are described. Those measurements made it possible to define the thermophysical development of the material, and the natures of thermodegradation reactions and of the compounds produced, as well as the rates of formation of these compounds

MAJS: /-ABLATIVE MATERIALS/-PYROLYSIS/-REENTRY PHYSICS/-REINFORCED PLASTICS/-THERMAL DEGRADATION

74A10677

UTTL: Effects of insulator ablation on the operation of a quasi-steady MPD arc  
 AUTH: A/BOYLE, M. J.; B/JAHN, R. G.  
 American Institute of Aeronautics and Astronautics, Electric Propulsion Conference, 10th, Lake Tahoe, Nev., Oct. 31-Nov. 2, 1973, 11 p.  
 ABS: Multiringed operation of quasi-steady MPD arc jets can involve serious ablation of the insulator surfaces within the arc discharge chamber. Various degrees of insulator ablation manifest themselves by significant perturbing the voltage-current characteristics and the exhaust velocity profiles. Insulator current characteristics for two different insulator materials, Piciglas and Coran nitride, are interpreted in terms of an empirical Ohm's law. Use of the refractory insulator material eliminates the ablation-dominated nature of the terminal voltage, but the exhaust stream is still disturbed by insulator material. An Alfvén critical velocity model can be applied to this influence of insulator ablation on exhaust velocity. Appropriate changes in the propellant injection geometry eliminate this influence and result in arcjet operation which is independent of insulator material. A particular combination of propellant injection geometries reduces the terminal voltage for a given current and mass flow while maintaining insulator-independent operation, thus implying an improvement in the overall efficiency of

the device.

MAJS: /-ABLATION/-ARC JET ENGINES/-ELECTRICAL INSULATION/-EXHAUST VELOCITY/-MAGNETOHYDRODYNAMICS/-QUASI-STEADY STATES

74A10681

UTTL: A low current pulsed ablation plasma thruster  
 AUTH: A/LIEBIG, L.; B/SEIDEL, F.  
 American Institute of Aeronautics and Astronautics, Electric Propulsion Conference, 10th, Lake Tahoe, Nev., Oct. 31-Nov. 2, 1973, 11 p.  
 ABS: A new type of ablation plasma thruster has been investigated which delivers small impulse bits (10 to 100 micronewtons) in the msec pulse regime at a low voltage (100 V) and a low current (50 A) level. The accelerating mechanism is described in term of an electron pressure model. The thruster performance is greatly effected by electron heat conductivity which presently limits the thrust efficiency to 1%. On the basis of endurance tests an endurance capability of a total number of ten million impulse bits can be anticipated. Various solid materials were used as propellants, and their properties with respect to space applicability are discussed.

MAJS: /-ABLATIVE MATERIALS/-PLASMA ENGINES/-PROPULSION SYSTEM PERFORMANCE/-PULSED JET ENGINES/-SATELLITE ATTITUDE CONTROL

73A41419

UTTL: Ablation debris and primary micrometeoroids in the stratosphere.  
 AUTH: A/BRONLEE, D. E.; B/HODGE, P. W.  
 In: Space research XII: Proceedings of the Fifteenth Plenary Meeting, Madrid, Spain, May 10-24, 1972. Volume 2. (A73-41325 21-13) Berlin, East Germany. Akademie-Verlag GmbH, 1973, p. 1138-1151.

ABS: Analysis of micrometer-sized stratospheric particulates suggests that the majority of extraterrestrial material in the atmosphere is the product of ablation of larger bodies. Ablation debris is of considerable interest because of the possibility that much of it may have originated from classes of easily fragmented meteoroids that are incapable of surviving atmospheric entry to become meteorites. Comparison is made between the elemental abundance patterns found in stratospheric particulates and that found in fusion crusts of primitive meteorite types. Also discussed are criteria for distinguishing ablation products from primary unablated micrometeoroids.

MAJS: /-ABLATION/-EXTRATERRESTRIAL MATTER/-METEORITIC COMPOSITION/-MICROMETEORIDS/-STRATOSPHERE

72A41052

UTTL: Measuring the boundary layer temperature distributions using ablating specimens in an air plasma flow.  
AUTH: A/GEORG, E. B.; B/RULEV, I. U. K.; C/SIPACHEV, G. F.; D/IAKUSHIN, M. I.  
Heat Transfer - Soviet Research, vol. 5, July-Aug. 1973, p. 32-37. Translation.

ABS: The temperature distribution across the boundary layer at an ablating specimen was measured experimentally. The equipment used excluded contamination of the plasma by products of electrode damage thus ensuring more reliable results. The specimens used were recond-nose cylinders of asbestos-filled plastic. The experimental results suggest a model of a boundary layer for an ablating specimen in air plasma where the gas produced by ablation is removed at the body-gas interface normal to the body's surface. The boundary layer was found to separate. It was also found the heat is absorbed predominantly by reduction in the convective transfer upon penetration of ablation products into the boundary layer.

MAJS: /-ABLATION/ BOUNDARY LAYERS/-CONVECTIVE HEAT TRANSFER/-MAGNETOHYDRODYNAMIC FLOW/-TEMPERATURE DISTRIBUTION/-TEMPERATURE MEASUREMENT

72A38426

UTTL: MHW HSA reentry performance analysis.  
AUTH: A/QUINN, J. E.; B/KNIGHT, D. D.

In: Intersociety Energy Conversion Engineering Conference, 8th, Philadelphia, Pa., August 13-16, 1973. Proceedings. Addendum. (A73-38386 19-03) New York, American Institute of Aeronautics and Astronautics, Inc., 1973, p. 79-88.

ABS: The multithundred watt (MHW) radioisotope heat source is being developed for multimission use for space applications in the 1970s. The HSA (heat source assembly) must be designed to survive any potential mission aborts resulting in a reentry into the earth's atmosphere. The HSA performance during possible reentries is analyzed. Areas discussed are: aerodynamics, flight motions, reentry heating, reentry shield ablation, thermal stresses of HSA internal components, thermal stresses in reentry snield and impact velocities. The analytical techniques employed are discussed along with the most significant results. In all cases examined, the MHW HSA is shown to survive the reentry and to impact at velocities equal to or below the impact velocity capability of the HSA.

MAJS: /-ABLATION/-AERODYNAMIC HEATING/-HEAT SOURCES/-RADIOACTIVE ISOTOPES/-REENTRY EFFECTS/-SPACECRAFT POWER SUPPLIES

73A38428

UTTL: Aerothermal testing of the MHW heat source.  
AUTH: A/KNIGHT, D. D.; B/QUINN, J. E.  
In: Intersociety Energy Conversion Engineering Conference, 8th, Philadelphia, Pa., August 13-16, 1973. Proceedings. Addendum. (A73-38386 19-03) New York, American Institute of Aeronautics and Astronautics, Inc., 1973, p. 65-77.

ABS: A series of engineering test programs have been run for the purpose of obtaining data required in the design of the reentry protection, a graphite aeroshell, for the multithundred watt (MHW) radioisotope heat source. The tests include wind tunnel tests run to obtain the aerodynamic coefficients necessary for calculations of reentry orientation, stability, and motion. Tests to measure aerodynamic heating rates and distributions; hypersonic ablation tests run in an arc tunnel to determine aeroshell recession and shape change during simulated trajectories; ablation tests in subsonic flow to determine aeroshell heat and mass transfer characteristics prior to impact; and drop tests to measure the heat source impact velocity.

MAJS: /-ABLATION/-AERODYNAMIC HEATING/-HEAT SOURCES/-RADIOACTIVE ISOTOPES/-REENTRY EFFECTS/-WIND TUNNEL TESTS

73A37C20

UTTL: Some characteristics of the disintegration of glassy bodies in hot gas flows

AUTH A/APSHTEIN, E. Z.  
Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza, May-June 1973, p. 181-184. In Russian.

ABS: The intense ablation of a heat shield near the critical point is analyzed on the basis of an approximate analytical solution of the equations of motion of a liquid film and of an asymptotic solution in a gas layer in the presence of intense blowing. The conditions at the surface of glassy ablating bodies are discussed, and the ablation characteristics of such bodies are examined.

MAJS: /-ABLATION/-GAS FLOW/-GLASS/-HEAT SHIELDING/-HIGH TEMPERATURE GASES

73A35681

UTTL: Improved technology for multiwatt radioisotope heater units.

AUTH: A/BARSELL, A. W.; B/GORANSON, R. B.; C/CLEMENTS, P. R.  
Nuclear Technology, vol. 19, Aug. 1973, p. 117-125.  
The approach considered optimizes radioisotope heater units for long-life protection against credible

accident environments, while serving the largest practical number of missions at minimum weight and maximum safety. Safety and lower long-range qualification costs are increased through the use of an optimized design for multiple applications. Design and safety criteria are discussed together with questions of materials development, design parameters, concept comparisons, and development tests.

MAJS: /•ABLATIVE MATERIALS/•HEATING EQUIPMENT/•RADIOISOTOPE BATTERIES/•SPACECRAFT COMPONENTS

73A36358

UTTL: Generalized ablative flow in gaps and slots.

AUTH: A/COOPER, ...; B/PUTZ, K. E.  
American Institute of Aeronautics and Astronautics, Thermophysics Conference, 8th, Palm Springs, Calif., July 16-18, 1973. 12 p. AEC-supported research.

ABS: An analytical method of predicting the flow properties in gap regions about control surfaces of reentry vehicles has been developed. The method is particularly applicable to situations involving regions containing ablating surfaces. The analysis is based on a quasi-one-dimensional compressible-flow solution including the effects of area change, friction, heat transfer, mass addition, and shocks. The effects of wall roughness and boundary layer transition effects are also included. The solution technique consists of a finite-difference approximation to the equations of change. The boundary conditions are founded upon a matching of local upstream pressure and downstream pressure, when appropriate, determination of the upstream total temperature by matching gap flow to captured flow properties on the body, and by employing a steady-state mass and energy balance at the wall-gas interface.

MAJS: /•ABLATION/•COMPRESSIBLE FLOW/•CONTROL SURFACES/•FLOW CHARACTERISTICS/•GAPS/•REENTRY VEHICLES

73A36358

UTTL: Thermochemical properties of a silicone elastomeric ablator.

AUTH: A/COUCH, H. T.  
American Institute of Aeronautics and Astronautics, Thermophysics Conference, 8th, Palm Springs, Calif., July 16-18, 1973. 14 p.

ABS: Thermal and chemical properties of a silicone elastomer-based ablative are presented for temperatures up to 4000 R. Thermodynamic properties of the virgin and char material and pyrolysis reaction products are determined from analysis of in-depth

transient thermal response of one-half inch specimens exposed to radiant heating in an inert environment. Chemical species evolved during pyrolysis are identified using time-of-flight mass spectrographic and X-ray diffraction techniques. Statistical analysis of temperature uncertainties supported by comparative measurement confirm overall uncertainty in thermodynamic properties of less than plus or minus 20% and uncertainty in thermal conductivity of plus or minus 10%.

MAJS: /•ABLATIVE MATERIALS/•SILICONE RUBBER/•THERMOCHEMICAL PROPERTIES

73A36358

UTTL: Initial development of an ablative leading edge for the Space Shuttle orbiter.

AUTH: A/DAFCRNO, G.; B/GRAHAM, J.; C/TOMPKINS, S.  
American Institute of Aeronautics and Astronautics, Thermophysics Conference, 8th, Palm Springs, Calif., July 16-18, 1973. 11 p.

ABS: A state-of-the-art preliminary design for typical wing areas is developed. Seven medium-density ablator's (with/without honeycomb, flown on Apollo, Prime, X15A2) are evaluated. The screening tests include (1) leading-edge models sequentially subjected to ascent heating, cold soak, entry heating, post-entry pressure fluctuations, and touchdown shock, and (2) virgin/charred models subjected to bondline strains. Four materials (none molded) are found acceptable. The ESA 3560 HF and MOD 7 MC (an AVCO 30 pc elastomer) are selected. Roughness/recession degradation of low speed aerodynamics appears acceptable. The design, including attachments, substructure and joints, is presented.

MAJS: /•ABLATIVE MATERIALS/•FLIGHT SIMULATION/•HEAT SHIELDING/•LEADING EDGES/•SPACE SHUTTLE ORBITERS/•THERMAL PROTECTION

73A36355

UTTL: Four Space Shuttle wing leading edge concepts.

AUTH: A/NIBLOCK, G. A.; B/REEDER, J. C.; C/HUNEIDI, F.  
American Institute of Aeronautics and Astronautics, Thermophysics Conference, 8th, Palm Springs, Calif., July 16-18, 1973. 12 p.

ABS: A heat-pipe-cooled Space Shuttle orbiter wing leading edge was compared and evaluated against three alternate leading edge candidates: a refurbishable ablative design, and two other reusable versions employing coated columbium and carbon-carbon high-temperature segments. Each candidate concept was shown feasible in the Phase B environment. The reusable versions were all found to cost nearly the

same and substantially less than the nonreusable ablative version. However, since current Shuttle trajectories produce higher heating rates than those used in this study, the carbon-carbon and heat pipe concepts are now the prime candidates for Shuttle leading edge thermal protection.

MAJS: /\*ABLATIVE MATERIALS/\*COOLING SYSTEMS/\*LEADING EDGES/\*SPACE SHUTTLE ORBITERS/\*THERMAL PROTECTION/\*WINGS

73A36353

UTTL: ATJ-5 Graphite ablation at angle of attack.  
AUTH: A/Williams, R. R.  
American Institute of Aeronautics and Astronautics, Thermophysics Conference, 8th, Palm Springs, Calif., July 16-18, 1973, 8 p.

ABS: A method of mounting ablation models for testing at an angle of attack was developed and successfully used in the McDonnell Douglas Research Laboratories (MDRL) High Impact Pressure (HIP) arc heater facility. Hemispherically capped, 10 deg half-angle cone models ranging in size from 0.1 in. to 1.0 in. nose tip diam were tested at 0 to 20 deg angle of attack, 50 to 167 atm model impact pressure, and 1600 to 2000 Btu/lb stream bulk enthalpy. Results include model surface temperatures, model shape change histories, and model recession rates. The recession rate data are correlated with model angle of attack, nose tip diameter, impact pressure, stream centerline enthalpy, and Mach number.

MAJS: /\*ABLATION/\*ANGLE OF ATTACK/\*REENTRY EFFECTS/\*SPACECRAFT MODELS

73A36335

UTTL: Viscous effects in massively-ablating planetary entry body flow fields.  
AUTH: A/INGER, G. R.  
American Institute of Aeronautics and Astronautics, Thermophysics Conference, 8th, Palm Springs, Calif., July 16-18, 1973, 11 p.

ABS: An approximate analytical study of the nonsimilar viscous flow field downstream of the stagnation point on a strongly ablating blunted hypersonic bodies is described. This problem is an important one in determining the radiative and convective heating of planetary entry vehicles. The approach is based on a three-layered flow model consisting of an inner inviscid rotational flow region of ablation gas overlaid by a laminar or turbulent mixing layer and an outer inviscid shock layer interacting with the displacement effect of the blown gas. Some preliminary results of the application of this theory are given for the case of laminar flow with several

different types of surface mass transfer distributions.

MAJS: /\*ABLATION/\*ATMOSPHERIC ENTRY/\*BLUNT BODIES/\*FLOW DISTRIBUTION/\*HYPERSONIC VEHICLES/\*STAGNATION POINT/\*VISCIOUS FLOW

73A36326

UTTL: New thermodynamic functions for the C3 molecule.  
AUTH: A/PEARSON, W. E.; B/DAVY, W. C.  
AIAA Journal, vol. 11, Aug. 1973, p. 1207, 1208.

ABS: When graphite is used as ablation material in heat shields, very often a prominent carbon species vaporized into the stream is C3. The thermodynamic properties of the C3 molecule are, therefore, important in calculating transport phenomena in the ablation flow field. The nature of the C3 thermodynamic functions has been in doubt because of the uncertain contribution of the bending mode vibrations to the total internal energy of the molecule. An approach for overcoming these difficulties is considered. The results of the computations are presented in the form of graphs and approximating functions.

MAJS: /\*ABLATIVE MATERIALS/\*CARBON/\*MOLECULAR ENERGY LEVELS/\*THERMODYNAMIC PROPERTIES/\*TRANSPORT THEORY

73A36322

UTTL: Assessment of chemical nonequilibrium for massively ablating graphite.  
AUTH: A/LINCOLN, K. A.; B/HOME, J. T.; C/LIU, T.-M.  
AIAA Journal, vol. 11, Aug. 1973, p. 1198-1200.

ABS: Several types of artificial graphite have been irradiated by laser pulses in vacuum, and the composition of the resulting vapor cloud has been determined in situ by mass spectrometric techniques in order to gain information pertaining to nonequilibrium ablation of graphitic probes entering planetary atmospheres. Results are discussed in terms of variations in concentrations of carbon species from their equilibrium values, and plotted curves illustrate the effect of nonequilibrium ablation on radiative shielding for simulated Jupiter entry conditions.

MAJS: /\*ABLATION/\*CARBON/\*CHEMICAL EQUILIBRIUM/\*GRAPHITE

73A36316

UTTL: Surface ablation of silica-reinforced composites.  
AUTH: A/HSEH, C.-L.; E/SEADER, J. D.  
AIAA Journal, vol. 11, Aug. 1973, p. 1181-1187.

ABS: The ablation mechanism of a silica-reinforced composite is studied. Special attention is given to

the effects of the presence of gas bubbles within the molten layer and certain internal chemical reactions. The assumption of two-phase laminar-flow for the melt layer is used to characterize the process. The physical properties which appear in the governing equations are considered as functions of the void fraction within the molten layer. The governing equations of charge are simplified by adopting the model of constant drift velocities and are solved by the integration method. The void fraction is shown to have a substantial effect on the heat of ablation. The presence of gas bubbles affects the apparent viscosity, the effective thermal conductivity, the carbon-silica reactions, and the flow pattern of the molten layer. These effects vary with the magnitude of the stagnation enthalpy.

MAJS: /•ABLATION/•PHENOLIC RESINS/•REINFORCED PLASTICS/•  
SILICON DIOXIDE

73A36315

UTTL: Ablation and radiation coupled viscous hypersonic shock layers.

AUTH: A/ENGLE, C. D.; B/FARMER, R. C.; C/PIKE, R. W.  
AIAA Journal, vol. 11, Aug. 1973, p. 1174-1181.

ABS: Coupled ablator shock layer solutions for the stagnation point are presented for typical hyperbolic entry atmospheric flight conditions. These solutions were obtained by numerically solving the stagnation line shock layer equations and quasi-steady ablator equations. These equations included ablation and radiation coupling within the viscous shock layer, line and continuum radiation for both air and phenolic-nylon ablation species and local thermodynamic equilibrium throughout. The results presented provide a sound basis for understanding many of the processes characteristic of hypersonic shock layer heating.

MAJS: /•ABLATION/•ATMOSPHERIC ENTRY/•HYPERBOLIC REENTRY/•  
HYPERSONIC FLOW/•RADIATION EFFECTS/•SHOCK LAYERS

73A36223

UTTL: Fully coupled nongray radiating gas flows with ablation product effects about planetary entry bodies.

AUTH: A/SUTTON, K.  
American Institute of Aeronautics and Astronautics, Fluid and Plasma Dynamics Conference, 6th, Palm Springs, Calif., July 16-18, 1973, 13 p.

MAJS: /•ABLATION/•ATMOSPHERIC ENTRY/•GAS FLOW/•NONGRAY GAS/•  
RADIATIVE TRANSFER/•REENTRY VEHICLES

73A35272

UTTL: Tektite ablation - Some confirming calculations.  
AUTH: A/O'KEEFE, J. A.; III; B/SILVER, A. D.; C/CAMERON, W. S.; D/ACAMS, E. W.; E/WARMERCO, J. O.  
Journal of Geophysical Research, vol. 78, June 10, 1973, p. 3451-3496.

ABS: The calculation of tektite ablation has been recone. taking into account transient effects, internal radiation, melting and nonequilibrium vaporization of the glass, and the drag effect of the flanges. It is found that the results confirm the earlier calculations of Chapman and his group and of Adams and his co-workers. The general trend of the results is not sensitive to reasonable changes of the physical parameters. The ablation is predominantly by melting rather than by vaporization at all velocities up to 11 km/sec; this is surprising in view of the lack of detectable melt flow in most tektites. Chemical effects have not been considered.

MAJS: /•ABLATION/•AERODYNAMIC DRAG/•GLASS/•TEKTITES/•  
TRANSIENT RESPONSE

73A34609

UTTL: Edgewise tape wound components for use in rocket motors.

AUTH: A/BILLINGTON, K. M.  
Plastics Institute, Conference on Reinforced Plastics in Aerospace Applications, London, England, Apr. 5, 6, 1973, Paper, 28 p.

ABS: In the manufacture of ablative components for rocket motors there has often been a requirement for the fibers of reinforcing materials to be oriented in such a way that a correct balance is achieved between optimum char strength, heat flow, and insulation characteristics of a liner for a given operating condition. The technique of edgewise tape winding has provided a most important contribution toward achieving this end. Special biased tapes were prepared to allow for the edgewise curvature necessary and a critical assessment has been made in establishing the most suitable condition required of the impregnating resin, with respect to tape manipulation, interlaminar tack curing lay-up, and adequate flow during curing operations. Where due consideration has been given to the advantages and limitation of the technique throughout design, value analysis and subsequent manufacturing processes, reinforced plastics ablative components have been produced that previously were neither practicable nor economical by traditional molding techniques.

MAJS: /•ABLATIVE MATERIALS/•FILAMENT WINDING/•REINFORCED  
PLASTICS/•ROCKET ENGINE DESIGN/•TAPES

73A34805

UTTL: Reinforced plastics under ablative conditions for thermal insulation and structural applications.

AUTH: A/LEAK'ONTH, G. S.  
Plastics Institute, Conference on Reinforced Plastics in Aerospace Applications, London, England, Apr. 5, 6, 1973, Paper, 7 p.

ABS: The materials considered include reinforced plastics based on phenolic or epoxide novolak resins with asbestos, glass, or silica fillers. Nylon or other organic fillers are also occasionally used together with a high proportion of inorganic fillers. Usually the main characteristics of ablative materials are conferred by the polymeric matrix of the compound. A polymer which shows high temperature resistance may be used. Other materials employed will degrade at a relatively low temperature, giving a high yield of carbon in a form appropriate to the formation of a resistant surface layer. Details of the pyrolysis of the matrix are discussed together with mechanical properties and thermal conductivity.

MAJS: /\*ABLATIVE MATERIALS/\*COMBUSTION CHAMBERS/\*REINFORCED PLASTICS/\*SPACECRAFT STRUCTURES/\*THERMAL INSULATION

73A33060

UTTL: Low-cost fabrication and installation of ablative heat shield for the space shuttle orbiter.

AUTH: A/MORROD, L. B.  
In: New Horizons in Materials and Processing: Proceedings of the Eighteenth National Symposium and Exhibition, Los Angeles, Calif., April 3-5, 1973. (A73-33026 16-18) Azusa, Calif.: Society for the Advancement of Material and Process Engineering, 1973, p. 471-480. NASA-sponsored reprint.

ABS: Description of the formulation and evaluation of low-density elastomeric ablative compounds and low-cost techniques for fabricating and installing ablative panels being considered for the Space Shuttle orbiter's thermal protection system. Sixteen large panels, both flat and contoured, were successfully fabricated and time-subjected to develop and refine tooling and manufacturing methods and to establish a realistic baseline for estimating costs. Six of the panels were bonded to a DC-3 airframe. The work included a detailed estimate of fabrication and installation costs.

MAJS: /\*ABLATIVE MATERIALS/\*ELASTOMERS/\*HEAT SHIELDING/\*SPACE SHUTTLE ORBITERS/\*THERMAL PROTECTION

73A30983

UTTL: Ablation coefficient and maximum brightness of a meteor.

AUTH: A/SHESTAKA, I. S.  
(Astronomicheskii Vestnik, vol. 6, July-Sept. 1972, p. 186-194.) Solar System Research, vol. 6, no. 3, Apr. 1973, p. 166-172. Translation.

ABS: (For abstract see issue of, p. 101. Accession no. A73-10847)

MAJS: /\*ABLATION/\*ATMOSPHERIC DENSITY/\*LUMINOUS INTENSITY/\*METEOR TRAILS

73A30133

UTTL: Chemical aspects of ablation.

AUTH: A/LADACKI, W.  
In: Chemistry in space research. (A73-30126 14-06) New York, American Elsevier Publishing Co., Inc., 1972, p. 253-318.

ABS: Ablation cooling can be defined roughly as a sacrificial loss of surface material for thermal protection of the underlying structure. The principles of ablation are examined, giving attention to reentry conditions, thermal control in reentry, and the equations of ablation cooling. The chemical environment in reentry is considered together with the chemical environment in propulsion and the nature of chemical reactions. The reactions taking place at the ablator surface are investigated, taking into account vaporization and sublimation, the surface pyrolysis of plastics, surface reactions in reentry, and surface reactions in propulsion. Reactions in the interior of a charring ablator are also discussed along with individual ablative materials and some specific applications as, for instance, the Mars entry.

MAJS: /\*ABLATIVE MATERIALS/\*REENTRY SHIELDING/\*SURFACE REACTIONS/\*THERMAL PROTECTION

73A28806

UTTL: Nonlinear least squares - An aid to thermal property determination.

AUTH: A/CURRY, D. M.; B/WILLIAMS, S. D.

ABS: AIAA Journal, vol. 11, May 1973, p. 670-674.  
Nonlinear least squares techniques can be used to determine effective thermal conductivity values from experimental data. Comparisons between measured and predicted conductivity values indicate that the analytically determined values can be used with confidence in performing thermal protection system analyses. A study was performed to compare the relative efficiencies of different minimizing techniques; the method of Peckham was the most



efficient.

MAJS: /\*ABLATIVE MATERIALS/\*LEAST SQUARES METHOD/\*THERMAL CONDUCTIVITY

73A28750

UTTL: Derivation of shape change equations for asymmetrically heated ablating reentry vehicles.

AUTH: A/NEUPINGER, J. L.

International Journal of Engineering Science, vol. 11, Apr. 1973, p. 451-457.

MAJS: /\*ABLATION/\*AERODYNAMIC HEATING/\*CONICAL BODIES/\*REENTRY EFFECTS/\*REENTRY VEHICLES/\*SPHERES

73A20479

UTTL: The development of a high-pressure plasma torch for heating air

AUTH: A/GEBEL, R.

Siemens Forschungs- und Entwicklungsberichte, vol. 2, no. 2, 1973, p. 79-84. In German. Research supported by the Bundesministerium fuer Forschung und Technologie und Gesellschaft fuer Weltraumforschung.

ABS: High-energy electric arc heaters produce a plasma because ionization of the gas involved takes place at the high operational temperatures of the device. The requirements of electric arc heaters intended for the heating of air are examined, giving particular attention to aerodynamic research applications including reentry studies. The principles of operation and the design of high-pressure arc heaters are discussed together with the results obtained in tests conducted to explore the effect of the air flow rate and the air pressure on the operational parameters.

MAJS: /\*ABLATION/\*GAS HEATING/\*HIGH TEMPERATURE AIR/\*HYPERSONIC WIND TUNNELS/\*PLASMA JETS

73A27008

UTTL: An experimental method for determining the characteristics of ablative materials

AUTH: A/GIORDANO, S.; B/BENECCHI, S.

Istituto Internazionale delle Comunicazioni, Convegno Internazionale delle Comunicazioni, 20th, Genoa, Italy, Oct. 8-13, 1972. Paper, 30 p. In Italian.

ABS: Description of an experimental arrangement which makes it possible to record certain characteristics, such as the temperature profile and the ablation velocity, of samples of ablative materials. After giving particulars concerning the realization of the installation, the measurement methods employed and experimental results obtained with samples of Teflon are outlined. The results obtained, collected in experimental diagrams, clearly show the various stages

of the pyrolysis of Teflon. In particular, the layer of depolymerized gases between the solid surface and the boundary layer. This gas layer is characterized by a certain stability of the temperature, which remains somewhat lower than that of the asymptotic stream. Most of the ablative phenomena occur in this zone.

MAJS: /\*ABLATIVE MATERIALS/\*PYROLYSIS/\*TEFLON (TRADEMARK)/\*TEMPERATURE EFFECTS/\*TEST EQUIPMENT

73A26402

UTTL: A mechanism for ablation-induced spin-up.

AUTH: A/ERICSSON, L. E.; B/PRICE, D. A.; JR.

AIAA Journal, vol. 11, Apr. 1973, p. 567-569.

ABS: Description of a mechanism for spin-up at zero angle of attack on a symmetric, perfectly balanced vehicle. It is shown that there is a mechanism through which ablation grooves can cause a spin-up. It is noted that, once the ablation groove has reached a certain depth, an 'internal' groove vortex-shedding phenomenon will cause the groove to deepen with out changing direction. The groove increases in depth along the direction set by the sublayer flow conditions until it becomes deep enough to affect the external flow.

MAJS: /\*ABLATION/\*REENTRY EFFECTS/\*REENTRY VEHICLES/\*ROTATING BODIES/\*SPIN DYNAMICS/\*ZERO ANGLE OF ATTACK

73A26376

UTTL: Decomposition rate of a phenolic resin.

AUTH: A/BISHOP, W. M.; B/MINKOWYCZ, W. J.

AIAA Journal, vol. 11, Apr. 1973, p. 438-443.

ABS: A test procedure and method of analysis is presented, whereby the overall decomposition rate of the phenolic binder in a silica-phenolic ablator may be separated into its component reactions. The Arrhenius rate equations for these separate reactions are then determined and a reaction mechanism is postulated which predicts the decomposition rate of the phenolic for both constant and varying test temperatures. To the best of the authors' knowledge, this is the first theory which accurately describes the decomposition rate of phenolic resin, and the method should be applicable to other high'y cross-linked polymers.

MAJS: /\*ABLATIVE MATERIALS/\*BINDERS (MATERIALS)/\*DECOMPOSITION/\*PHENOLIC RESINS/\*REACTION KINETICS

73A25779

UTTL: Temperature gradients and atmospheric ablation rates for the Barwell meteorite.

AUTH: A/SEARS, D. W.; B/MILLS, A. A.  
Nature Physical Science, vol. 242, Mar. 12, 1973, p. 25, 26.

MAJS: /-ABLATION/-ATMOSPHERIC ENTRY/-STONY METEORITES/-TEMPERATURE GRADIENTS

73A25720

UTTL: Investigation of heatproof materials under unsteady operating conditions

AUTH: A/PARKHATOV, B. M.; B/ALIFANOV, O. M.; C/IVANOV, A. A.; D/WARKIN, A. O.  
Inzhenerno-Fizicheskii Zhurnal, vol. 24, Jan. 1973, p. 75-83. In Russian.

ABS: The influence of unsteady external-flow parameters on the hypersonic heating and ablation of spacecraft heat shields is analyzed, and an analytical model of unsteady-state ablation is derived. The problem of determining the boundary conditions at the body in experimental investigations of unsteady-state heating and ablation is examined. An implicit finite-difference scheme for calculating transient thermal conditions at the surface of a plate with temperature-dependent characteristics is proposed.

MAJS: /-ABLATIVE MATERIALS/-HEAT SHIELDING/-HYPERSONIC HEAT TRANSFER/-REFRACTORY MATERIALS/-SPACECRAFT SHIELDING/-UNSTEADY FLOW

73A25510

UTTL: Laser activated, model surface recession compensator system for testing ablative materials.

AUTH: A/WILLIAMSON, R. A.; B/RICHART, W. A.; C/WILLIAMS, R. R.  
AIAA, ASME, and SAE, Structures, Structural Dynamics, and Materials Conference, 14th, Williamsburg, Va., Mar. 20-22, 1973, AIAA 7 p.

ABS: The purpose of this work was to develop an automatic surface recession compensator system to keep an ablating model in the constant pressure region of a high-pressure hypothermal arc heater environment. A laser system was incorporated into the control circuitry of the model axial drive system in the McDonnell Douglas Research Laboratories (MDRL) High Impact Pressure (HIP) arc heater facility. As model recession occurs during tests, the drive system automatically compensates for the axial displacement to maintain the front surface of the model at a virtually fixed position relative to the arc heater nozzle exit. This system consists of a laser, a detector with a plus or minus 10 A bandpass filter,

an amplifier and control relay, a Gilman slide for model axial positioning, and a potentiometer and encoder readout system.

MAJS: /-ABLATIVE MATERIALS/-ARC HEATING/-HYPERVELOCITY WIND TUNNELS/-MATERIALS TESTS/-MECHANICAL DRIVES/-WIND TUNNEL APPARATUS

73A25509

UTTL: Erosion of cork in a high velocity dust environment.

AUTH: A/HILLBERG, L. H.  
AIAA, ASME, and SAE, Structures, Structural Dynamics, and Materials Conference, 14th, Williamsburg, Va., Mar. 20-22, 1973, AIAA 7 p.

ABS: The erosion of phenolic cork in a high velocity dust environment was examined experimentally using specially modified hypersonic wind tunnels. Dust particle impact velocities varied from 1100 to 4490 ft/sec; particle materials included silicon carbide, aluminum oxide, magnesium oxide, tungsten carbide, and glass; particle sizes varied from 25 to 920 microns in diameter; and impact angles varied from 2 to 20 deg. Results are presented which indicate that over the range of conditions examined, the erosion of cork is independent of particle velocity and size and is strongly dependent on impact angle and specimen temperature. A procedure for predicting cork erosion is also presented.

MAJS: /-ABLATIVE MATERIALS/-CORK (MATERIALS)/-DUST/-EROSION /-PHENOLIC RESINS/-WIND EFFECTS

73A25307

UTTL: Materials for radomes.

AUTH: A/OTT, J. D.  
In: International Conference on Electromagnetic Windows, 2nd, Paris, France, September 8-10, 1971. Proceedings, Volume 3, (A73-25276 11-09) Paris. Direction Technique des Constructions Navales, 1972, p. 859-865, 867, 869.

ABS: A unique design in ablative radomes was recently successfully tested on the rocket sled track at Holloman AFB, with electrical transmission during flight. The design used a noncharring ablator (Avcoat 8021), cast directly to a fiberglass substructure, allowing a simple low-cost product. The radome demonstrated predicted thermal protection and exhibited negligible effects on the electrical transmission at the frequency of interest. The actual radome shape was modeled by subdividing the body into combinations of simple shapes (spheres and cones), thereby making the available empirical solutions applicable.

MAJS: /-ABLATIVE MATERIALS/-AERODYNAMIC HEATING/-MISSILE

# DESIGN/RADIO TRANSMISSION/RADOME MATERIALS/THERMAL PROTECTION

73A22622

UTTL: Determination of the electron concentration in the boundary layer of air mixed with ablation products of an asbestos plastic

AUTH: A/KHLYBOV, G. N.; B/IAKUSHIN, M. I.

PWTF - Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki, Sept.-Oct. 1972, p. 174-177. In Russian.

MAJS: /ABLATION/ASBESTOS/SECONDARY LAYER COMBUSTION/ELECTRON DENSITY (CONCENTRATION)/HIGH TEMPERATURE AIR

73A22573

UTTL: Ablation of large meteor particles

AUTH: A/BABADZHANOV, P. B.; B/GETMAN, V. S.

Akademika Nauk Tadzhikskoi SSR, Doklady, vol. 15, no. 11, 1972, p. 19-22. In Russian.

ABS: Photographic meteor observations are used to determine the changes in the ratio of the heat transfer coefficient to the specific energy of ablation during the motion of meteors. Good agreement is obtained between the theoretical and experimental results for the logarithm of this ratio as a function of the logarithm of atmospheric density for sporadic meteors and Taurids meteors.

MAJS: /ABLATION/HEAT TRANSFER COEFFICIENTS/METEOROID/SPECIFIC HEAT

73A21817

UTTL: Stagnation region radiative heating with steady-state ablation during Venus entry.

AUTH: A/TION, K.; B/FALANGA, R. A.

Journal of Spacecraft and Rockets, vol. 10, Feb. 1973, p. 155-157.

MAJS: /ABLATION/ATMOSPHERIC ENTRY/RADIATION ABSORPTION/RADIATIVE HEAT TRANSFER/VENUS ATMOSPHERE

73A21632

UTTL: Electrode ablation in an electromagnetic shock tube.

AUTH: A/SHARAH, A.; B/CORMACK, G. D.

Canadian Journal of Physics, vol. 51, Feb. 1, 1973, p. 229-235. National Research Council of Canada

ABS: Electrode ablation in a rail type of electromagnetic shock tube has been studied. Cathode ablation was found to be present over a wide range of experimental parameters whereas anode ablation was found to be immeasurably small. The parameters varied included the drive current, gas pressure, and the electrode

material. Observations of current sheet velocity were interpreted as evaporation of cathode material from cathode spots. The ablation series determined from velocity data for the metals tested was: mild steel, Zn, Cu, Mo, in order of decreasing amount of ablation. MAJS: /ABLATION/CURRENT SHEETS/ELECTROMAGNETIC PULSES/PARALLEL PLATES/PLASMA ELECTRODES/SHOCK TUBES

73A21369

UTTL: Method of determining the mass removal from heat-shield materials on the basis of strain measurements in loaded shells

AUTH: A/KORCLEV, V. P.; B/NIKULIN, M. V.; C/UVAROV, V. N.; D/CHERNENKO, G. E.

Mekhanika Polimerov, Sept.-Oct. 1972, p. 824-828. In Russian.

MAJS: /ABLATIVE MATERIALS/HEAT SHIELDING/MASS TRANSFER/SHELL THEORY/STRESS MEASUREMENT

73A19975

UTTL: Effect of low heat-shield ablation rates on flight test turbulent base pressure.

AUTH: A/BULKER, B. M.

AIAA Journal, vol. 10, Dec. 1972, p. 1704, 1705. AEC-supported research.

ABS: Review of new flight test data for two reentry vehicles having very low heat shield ablation rates in turbulent flow. These new data, which represent the lowest ablation rates reported for ablating vehicles, are compared with other recent flight data and are shown to provide additional evidence that even very low mass addition may produce substantial increases in turbulent base pressure.

MAJS: /ABLATION/BASE PRESSURE/FLIGHT TESTS/HEAT SHIELDING/REENTRY VEHICLES/TURBULENT FLOW

73A19486

UTTL: Effect of additives on ablation of phenolic-silica composites.

AUTH: A/CHICLEY, J. D.; B/SEADER, J. D.

Journal of Spacecraft and Rockets, vol. 10, Jan. 1973, p. 7-14.

ABS: The behavior of three additives, Cr2O3, Fe, and Fe2O3, incorporated into the resin phase of a typical phenolic-silica charring-ablative material, was investigated. The performance, as indicated by the overall char depth, of additive-containing ablators relative to that of identically fabricated control material was evaluated during exposure to two different environments, provided by an arc-imaging furnace and by a small hybrid rocket motor employing

polymethylmethacrylate/oxygen propellants. Important improvements in ablator performance were observed, particularly in the more extreme hybrid-rocket-motor tests. Char samples were examined by means of scanning-electron microscopy. Composites containing Cr2O3 exhibited the least reduction in char depth. The effect of Fe was an overall char-depth reduction of about 10%. The largest reduction in the char depth, ranging up to 30%, was observed in composites containing Fe2O3. Results of microscopic examinations were consistent with the hypothesis that the decrease in char depth was due mainly to heat absorption by endothermic reduction of iron oxides

MAJS: /\*ABLATIVE MATERIALS/\*ADDITIVES/\*PHENOLIC RESINS/\*  
REINFORCED PLASTICS/\*SILICON DIOXIDE

73A10381

UTTL: Effects of nonequilibrium ablation chemistry on Viking radio blackout.

AUTH: A/EVANS, J. S.; 8/SCHEXNAYDER, C. J.; JR.; C/GROSE, W. L.

American Institute of Aeronautics and Astronautics, Aerospace Sciences Meeting, 11th, Washington, D.C., Jan 10-12, 1973, 7 p.

ABS: The length of the entry blackout period during descent of the Viking Lander into the Mars atmosphere is predicted from calculated profiles of electron density in the shock layer over the aeroshell. Nonequilibrium chemistry plays a key role in the calculation. This is the inviscid flow and in the boundary layer. This is especially true in the boundary layer contaminated with ablation material, for which nonequilibrium chemistry predicts electron densities two decades lower than the same case calculated with equilibrium chemistry.

MAJS: /\*ABLATION/\*ATMOSPHERIC CHEMISTRY/\*ATMOS. HERIC ENTRY/\*  
BLACKOUT (PROPAGATION)//-VIKING LANDER SPACECRAFT

73A15826

UTTL: Effects of a fully catalytic wall on a non-equilibrium boundary layer including ablation products.

AUTH: A/BRAUN, E. R.

American Society of Mechanical Engineers, Winter Annual Meeting, New York, N.Y., Nov. 26-30, 1972, 14 p.

MAJS: /\*ABLATION/\*CATALYTIC ACTIVITY/\*HYPERSONIC BOUNDARY  
LAYER/\*NONEQUILIBRIUM FLOW

73A15731

UTTL: Low-power ablation plasma thruster.

AUTH: A/LIEBIG, L.; B/SEIDEL, F.

In: Electric propulsion and its space applications: Workshop, 2nd, Toulouse, France, June 21-23, 1972. Proceedings. (A73-15712 04-28) Toulouse, Centre National de la Recherche Scientifique, 1972, p. 225-235.

ABS: A small pulsed plasma thruster was designed for small impulse bits in the 100 micronewton-sec range. The discharge is quasi-stationary (10 msec) and runs at a low voltage (50 volt) and low current (10 amp) levels. A small magnetic field (400 gauss) is applied to form an ablating anode attachment. The performance compares with the LES-6 pulsed plasma thruster.

MAJS: /\*ABLATION/\*LOW THRUST PROPULSION/\*PLASMA ENGINES/\*  
PULSED JET ENGINES/\*ROCKET ENGINE DESIGN

73A14189

UTTL: Role of the anelastic behavior of the ablator material on cross-hatching.

AUTH: A/STOCK, H. W.

AIAA Journal, vol. 10, Nov. 1972, p. 1528, 1529.

ABS: Explanation of the physical mechanism which generates cross-hatched surface patterns on ablating bodies exposed to a supersonic turbulent boundary-layer flow. The assumption made by Probst and Gold (1970) that the velocity of the moving viscous solid equals the velocity of the supersonic gas stream is questioned, and, consequently, their conclusion that

cross-hatching results from a differential surface deformation of an anelastic deformable material. An alternative calculation method is presented, retaining the basic ideas and the type of analysis figuring in Probst and Gold's calculations. It is shown that, in contrast to the results of Probst and Gold, the amplification factor is a unique function of the Mach number and is independent of the disturbance wavelength, the material properties, and the factor describing the proportionality between fluctuations in pressure and shear stress.

MAJS: /\*ABLATION/\*ANELASTICITY/\*BOUNDARY LAYER FLOW/\*  
SUPERSONIC BOUNDARY LAYERS/\*SURFACE PROPERTIES/\*  
TURBULENT BOUNDARY LAYER

73A13457

UTTL: Continuing development of the short-pulsed ablative space propulsion system.

AUTH: A/PALUMBO, D. J.; B/GUNAN, W. J.

American Institute of Aeronautics and Astronautics and Society of Automotive Engineers, Joint Propulsion Specialist Conference, 8th, New Orleans, La., Nov.

29-Dec. 1. 1972. AIAA 7 p.

**ABS:** Major advancements have been made in solid propellant pulsed plasma propulsion technology. A LES-6 microthruster has operated for 8900 hours in orbit. Millipound thrusters have been developed and tested at performance levels of as low as 112 watts/mlb. Efficiencies of up to 50% and specific impulse values up to 5000 sec have been measured. An improved microthruster has operated at 207 watts/mlb continuously for 1440 hours. Correlations of design and performance data exist to allow thrusters to be built to meet a particular level of performance.

**MAJS:** /\*ABLATIVE MATERIALS/\*MICROCKET ENGINES/\*PLASMA PROPULSION/\*PROPULSION SYSTEM PERFORMANCE/\*PULSE DURATION/\*SOLID ROCKET PROPELLANTS

73A13044

**UTTL:** Pyrolytic carbon-carbon materials.  
**AUTH:** A/GEBHARDT, J. J.; B/YCDSNUKIS, J. J.; C/STOVER, E. R.

In: Non-metallic materials selection, processing and environmental behavior: Proceedings of the Fourth National Technical Conference and Exhibition, Palo Alto, Calif., October 17-19, 1972. (A73-13001 03-18) Azusa, Calif.: Society of Aerospace Material and Process Engineers, 1972, p. 507-523.

**ABS:** Carbon-carbon composites generally consist of prescribed arrays of carbon or graphite fibers within a carbon or graphite matrix. The latter may be formed by pyrolytic decomposition of a hydrocarbon gas under a variety of conditions designed to achieve uniform density and distribution of the matrix around the fibers. Important considerations include the geometry and packing density of the woven structure as well as the conventional pyrolysis parameters of temperature, pressure and gas flow rate. A number of approaches have been tried which depend on achieving a temperature gradient within the weave which reduces the tendency for excessive surface deposition. A study is made of the effect of the weave geometry on the infiltration process and structure of the resulting composite.

**MAJS:** /\*ABLATIVE MATERIALS/\*CARBON FIBERS/\*COMPOSITE STRUCTURES/\*HEAT SHIELDING/\*PYROLYTIC GRAPHITE

73A12255

**UTTL:** Meteor dust motion in the upper atmosphere and in the vicinity of the earth's orbit.  
**AUTH:** A/LEBEDINETS, V. N.; B/MANOCHINA, A. V.; C/SHUJHKOVA, V. B.

In: Space research XII: Proceedings of the Fourteenth Plenary Meeting, Seattle, Wash., June 18-July 2, 1971.

Volume 1. (A73-12226 02-30) Berlin, East Germany: Akademie-Verlag GmbH, 1972, p. 309-312.

**ABS:** The problem of the transition of small solid particles of interplanetary medium from heliocentric to geocentric orbits under the action of aerodynamic deceleration when incident tangentially on the upper layers of the atmosphere is solved. Deceleration and ablation of particles in the atmosphere are computed with provision for the energy loss on heating, evaporation and thermal radiation and the loss of mass due to evaporation and sputtering. The zones of capture were found to be much broader than those evaluated by other authors earlier. Although the role of 'aerodynamical capture' of interplanetary dust by the upper atmosphere in the formation of the earth's dust cloud is less than that of gravitational focusing, it can lead to an appreciable increase of dust concentration over some regions of the earth at altitudes of 100-200 km when the earth meets a meteor stream.

**MAJS:** /\*ABLATION/\*DECELERATION/\*INTERPLANETARY DUST/\*METEORIDS/\*TRANSFER ORBITS/\*UPPER ATMOSPHERE

73A11448

**UTTL:** Phenolic resin char-formation during hyperthermal ablation.

**AUTH:** A/FARVER, R. W.

(North American Thermal Analysis Society, Annual Meeting, 3rd, Waco, Tex., Feb. 7, 8, 1972.)

Thermochimica Acta, vol. 4, Aug. 1972, p. 223-238.

**ABS:** The surface of a carbonaceous char is lost during the ablation of fiber-reinforced phenolic resin composites. The transient high temperatures penetrate deeply, resulting in an underlying pyrolysis zone with rapid pyrolysis rates and a high char interface temperature. Phenolic resin char-formation at high heating rates and high temperatures was studied using thermogravimetry (TG). The specialized thermobalance permitted runs in helium at rates of 3-430 C/min up to 1400 C. Computer code analysis provided rate parameters for an Arrhenius type correlation. The parameters represented well the parent TG run but were not independent of heating rate. A complex correlation was considered necessary for universal use. The attractive alternative was parameter evaluation at high heating rates using TG.

**MAJS:** /\*ABLATION/\*CHARRING/\*PHENOLIC RESINS/\*REINFORCING FIBERS

73A10847

UTTL: Ablation coefficient and maximum brightness of meteors

AUTH: A/SHESTAKA. I. S.

Astronomicheskii Vestnik, vol. 6, July-Sept. 1972, p. 106-104. In Russian.

ABS: Statistical analysis of data on photographed bright meteors reveals an explicit dependence of the ablation coefficient on the velocity of meteoric bodies and the atmospheric density. The decrease in the ablation coefficient in the transition from slow to fast meteors and from lower- to higher-density regions of the atmosphere is attributed to the increased screening effect of the separating and ablating molecules and to an increase in the effective ablation heat. The fact that the observed maximum brightnesses exceed the theoretical ones indicates that the nature of ablation changes during the meteor flight.

MAJS: /\*ABLATION/\*ATMOSPHERIC DENSITY/\*BRIGHTNESS  
TEMPERATURE/\*METEOR TRAILS